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Computer program for calculating in-flight aircraft-store interface reaction loads.

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THESIS

COMPUTER PROGRAM FOR CALCULATING IN-FLIGHT AIRCRAFT-STORE INTERFACE REACTION LOADS

by

Stephen A. Modzelewski

DECEMBER 1991

Thesis Advisor: E.R. Wood

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This thesis utilizes Military Specification, Mil-A-8591H, to provide and document a new computer program for calculating store reaction forces, due to inertial loads and airloads, at the aircraft-store interface. Due to the fact that the store is a statically indeterminate structure with unknown flexibility characteristics, the analysis to calculate the reaction forces is a relatively complex problem. The program was written to incorporate new requirements and techniques for calculating reaction loads at the aircraft-store interface in accordance with Mil-A-8591 revision H. This computer program was developed to be used on the VAX/VMS Computer System, Advanced Computational Laboratory, of the Aeronautics and Astronautics Department, Naval Postgraduate School. A detailed User's Manual which is included in Appendix A of this thesis was written to accompany the computer program. The computer program will enable graduate students in the Aircraft, Helicopter and Missile Design courses to utilize current military specifications for preliminary design and weapon system integration.

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Computer Program for Calculating In-Flight Aircraft-Store Interface Reaction Loads

by

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis utilizes Military Specification, Mil-A-8591H, to provide and document a new computer program for calculating store reaction forces, due to inertial loads and airloads, at the aircraft-store interface. Due to the fact that the store is a statically indeterminate structure with unknown flexibility characteristics, the analysis to calculate the reaction forces is a relatively complex problem. The program was written to incorporate new requirements and techniques for calculating reaction loads at the aircraft-store interface in accordance with Mil-A-8591 revision H. This computer program was developed to be used on the VAX/VMS Computer System, Advanced Computational Laboratory, of the Aeronautics and Astronautics Department, Naval Postgraduate School. A detailed User's Manual which is included in Appendix A of this thesis was written to accompany the computer program. The computer program will enable graduate students in the Aircraft, Helicopter and Missile Design courses to utilize current military specifications for preliminary design and weapon system integration.

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THESIS DISCLAIMER

The computer program was written to provide a simplified analysis for preliminary design. The program was written according to the methods and equations provided by military specification but has not been tested for all cases. Any application of this program without additional verification is at the risk of the user.

I. INTRODUCTION

The design of a new military aircraft is predicated on what stores the aircraft is required to carry. A major design consideration for aircraft and aircraft systems is the interface between the aircraft and the store.

Due to the fact that the store is a <u>statically indeterminate structure with unknown flexibility characteristics</u>, the analysis to calculate the reaction on the store suspension equipment is a relatively complex problem. By making several assumptions, the problem can be simplified so a general analysis can be performed for stores and aircraft that are still in the preliminary design stage.

Military specification MIL-A-8591H is the general guide for the integration of a store to an aircraft. It covers requirements that need to be considered in a store-aircraft integration, including the main focus of the specification of how inertial loads and airloads affect the aircraft store interface. Mil-A-8591H, Appendix D [Ref. 1], outlines an updated approach to analyze the results of specified inertial loads on a store-aircraft suspension equipment interface. The objective of this thesis is to provide a computer program and user's manual for calculating the reaction at a store-aircraft interface due to specified inertial loads and airloads in accordance with the method described in Mil-A-8591H, Appendix D [Ref. 1].

II. MILITARY SPECIFICATION MIL-A-8591H

Mil-A-8591 was first published in 1955, since then it has gone through several revisions until the most current version, Mil-A-8591H was published on 23 March 1990. One of the primary goals of the specification is to provide aircraft store standardization not only for the United States Department of Defense but also for NATO (North Atlantic Treaty Organization) countries. The specification contains detailed drawings for store hook and sway brace design requirements. The specification also provides general guidance for design, analysis, test and documentation of airborne stores, suspension equipment and the aircraft-store interface during captive operations. In addition to the general body of the specification there are four appendices that give detailed guidance to analyze the effects of inertial loads and airloads on the aircraft-store interface.

Mil-A-8591H, Appendix D [Ref. 1], provides an indepth method to analyze the reaction forces at the aircraft-store interface. Through the years there have been several analyses for the reaction forces at the aircraft store-interface. One of the most recent is contained in [Ref. 2]. The method of analysis in Mil-A-8591H was not addressed in previous revisions of the specification. The various analyses rely on basically the same information (i.e., store physical characteristics, store inertial loads, and store airloads) to provide reaction forces at the aircraft-store interface. The analyses are conservative and cover a broad category of stores and a wide range of aircraft. Once design considerations become more specific a more detailed analysis can be accomplished.

Mil-A-8591H, Appendix A [Ref. 1], provides store inertial loads and store airloads for the most general analyses. The store inertial loads for fixed wing high performance carrier based aircraft are provided. Also given are equations that provide maximum store angle-of-attack and maximum store angle-of-sideslip so that corresponding airloads can be calculated. As would be expected, the approach in Mil-A-8591H, Appendix A [Ref. 1] is the most conservative and covers a broad band of aircraft and stores. Note, that in Mil-A-8591H, Appendix A [Ref. 1], store envelopes are provided, yet no reference is made to aircraft envelopes.

Mil-A-8591H, Appendix B [Ref. 1], is more specific in that the inertial envelopes of specific types of aircraft are provided. In this case the store inertial loads must be calculated using the accompanying aircraft equations of motion. The analysis in Mil-A-8591H, Appendix B [Ref. 1], requires more specific information that is not always available during preliminary design. Since the analysis of Mil-A-8591H, Appendix B [Ref. 1], is for a specific aircraft-store combination, the results are less conservative than the results of the analysis of Mil-A-8591H, Appendix A [Ref. 1]. Note, in Mil-A-8591H, Appendix B [Ref. 1], in contrast to Mil-A-8591H, Appendix A [Ref. 1], aircraft envelopes are provided and the store envelopes must be calculated.

Mil-A-8591H, Appendix C [Ref. 1], is specifically for helicopters and the aircraft inertial envelopes are provided. The necessary equations to convert the aircraft inertial loads to store inertial loads are in Mil-A-8591H, Appendix B [Ref. 1]. Specific detailed information about aircraft and store physical characteristics are required. Mil-A-8591H, Appendix C [Ref. 1], provides no specific guidance to calculate airloads for a helicopter-store combination.

All analyses and envelopes provided in the specification are general in nature and all stores shall conform to the requirements of the specification, but the acquiring activity could prescribe more stringent or detailed requirements in the aircraft or store detailed specification.

III. AIRCRAFT STORES INTERFACE MANUALS (ASIM)

The ASIM manuals are a reference to provide engineers a source of information regarding the physical characteristics required in aircraft-store integration. The information provided by these manuals is essential for new aircraft design, new store design, and existing aircraft-store integration. Since future aircraft and aircraft system design builds on what already exists, the ASIM manuals are a good starting point for any aircraft-store analysis. The information in the ASIM manuals will be utilized in the Mil-A-8591H loads analysis. The ASIM manuals are divided into three volumes [Refs. 3, 4, and 5]. See Figure 1 for the organization of ASIM.

Volume 1 is the Aircraft Manual and it provides detailed drawings of current United States and NATO aircraft store stations. The manual is arranged into four sections and an introductory section.

The Introductory Section of Volume 1 ties together the other four sections by describing the contents and suggesting typical uses of the manual with an overview of store integration. In addition a chart is provide to indicate the suspension equipment currently being utilized on United States aircraft.

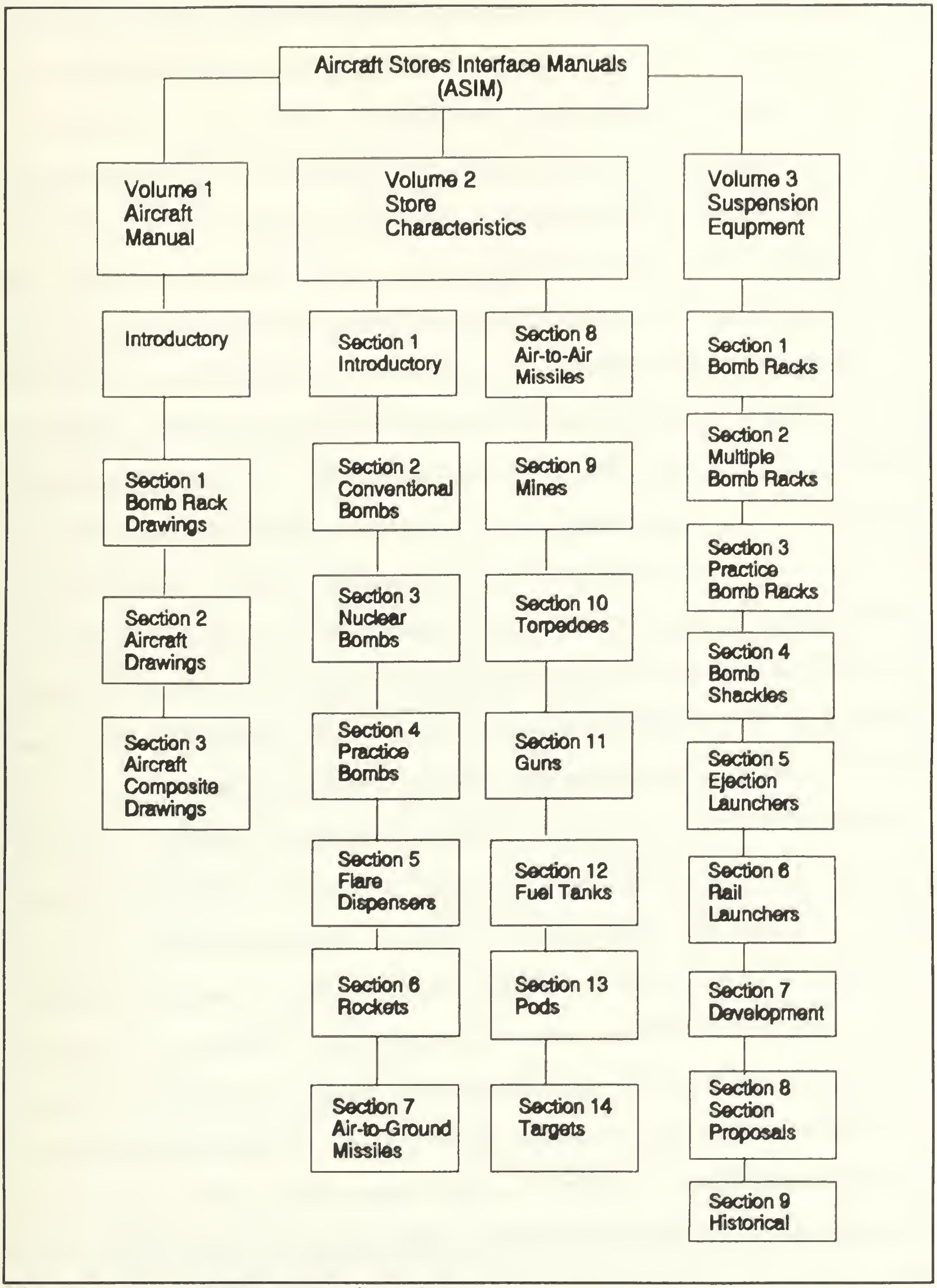


Figure 1. ASIM Organization

Section 1 of Volume 1 of the ASIM manual provides bomb rack drawings with associated dimensions for integration to the aircraft. Similar information is provided in Volume 3, only in much more detail and with respect to the entire bomb rack or suspension equipment. Section 2 of Volume 1 of the ASIM manual provides aircraft drawings of United States and NATO aircraft. The aircraft are presented giving a front view and side view together with dimensions required for store integration. Section 3 of volume 1 of the ASIM manual provides composite drawings of several aircraft so that clearance envelopes can be compared. The composite nature of the drawings allow a designer to determine which aircraft can accommodate a store and what clearance is available for a store designed for use on a variety of aircraft. Section 4 of Volume 1 of the ASIM manuals provides detailed drawings of the aircraft pylons to which the stores must attach.

Volume 2 is the Store Characteristics Manual and it provides detailed drawings of current stores utilized by the United States and NATO. The manual is broken down into 14 sections. The sections cover, Conventional Bombs, Nuclear Bombs, Practice Bombs, Flare Dispensers, Rockets, Air-To-Ground Missiles, Air-To-Air Missiles, Mines, Torpedoes, Guns, Fuel Tanks, Pods, and Targets. The primary dimensions, weights and mass moments of inertia are given for each store. In addition, the phone numbers and addresses of the design and field activities for each store are listed, if further information about a store is needed.

Volume 3 is the Suspension Equipment Manual, and it provides detailed drawings of the suspension equipment used by United States and NATO countries. The manual is broken down into sections describing various types of bomb racks and missile launchers. A detailed description of the suspension equipment capabilities and performance characteristics is also included. Also given are phone numbers and addresses of the design and field activities for each store. These are listed if further information about a store is sought.

IV. PROBLEM FORMULATION

A computer program has been developed to implement the store interface analysis contained in Mil-A-8591H, Appendix D. The analysis of Mil-A-8591H, Appendix D [Ref. 1], was not published in previous revisions of Mil-A-8591. Existing programs [Ref. 2] use a different approach in the analysis. Reference 2 analyses tandem hook/lug tandem sway brace configurations and single hook/lug (practice bombs) configurations. The basic premise of the following analysis is a tandem hook/lug tandem sway brace configuration, Figure 2. The objective of the analysis is, <u>given a specified flight envelope, to determine the worst case load at the aircraft-store interface (i.e., hook/lug and sway braces)</u>.

The basis of the analysis is a set of equations to determine the worst case load for a component given the inertial loads as specified in Mil-A-8591H. If airloads are applicable they must be converted to forces and moments about the store CG and added to the corresponding inertial loads. The computer program allows direct input of store accelerations due to aerodynamic effects and has the capability to perform a basic airload analysis from References 2, 6, and 7.

The overall problem is complex with many variables not available during preliminary design. In order to reduce the

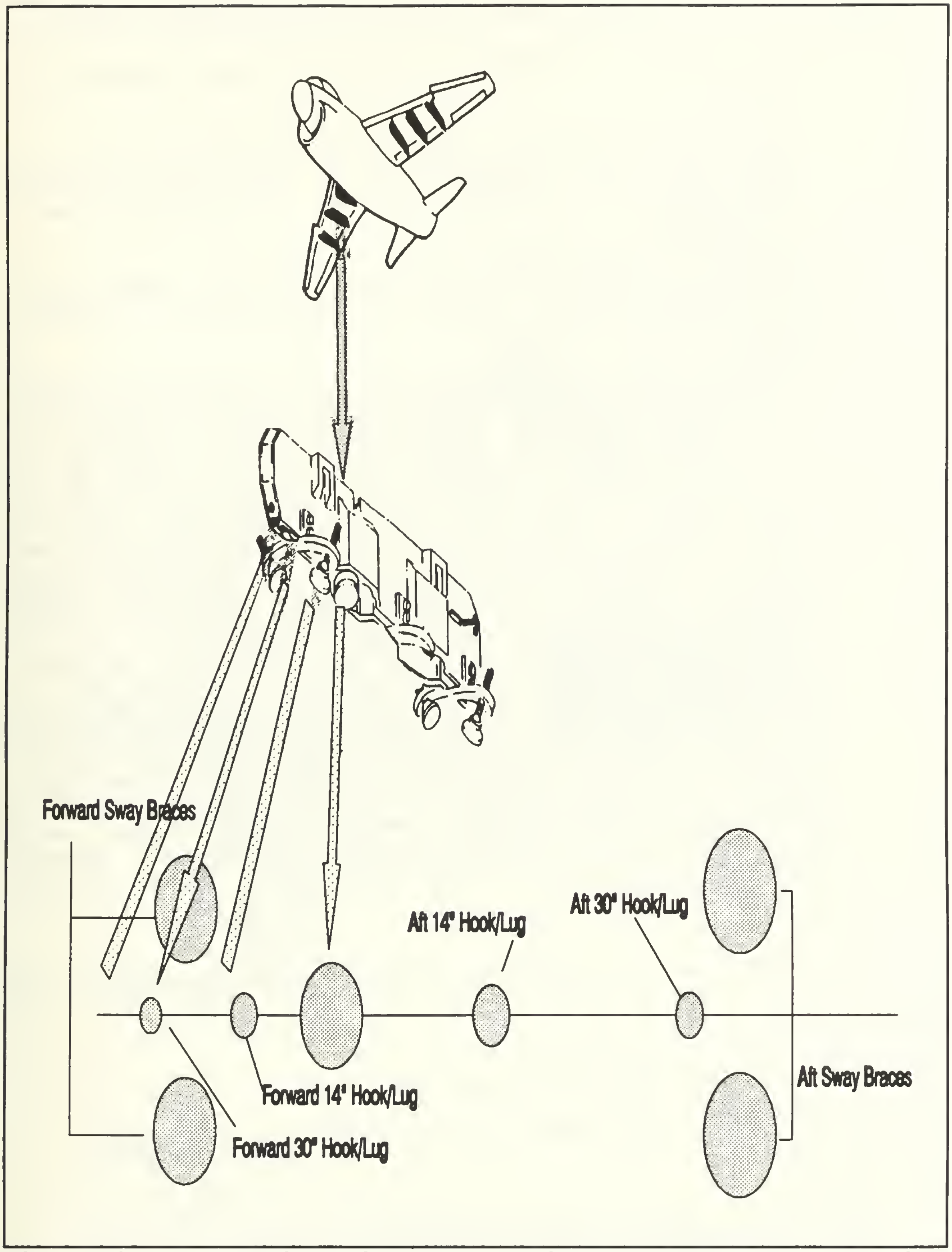


Figure 2. Relationship of Typical Bomb-Rack Top-View Drawing from Section 1 to the Actual Rack and the Carrying Aircraft

complexity of the problem (i.e., to a statically determinate structure) several assumptions are postulated. These are:

1. Treat the store as a rigid body. (Assuming the store a rigid body, the flexibility of the store, resultant load paths and modal bending are removed from the analysis.)

2. A sway brace can only react compressive loads, while a hook/lug can react both tensile vertical loads and shear loads.

3. The designer is only concerned with worst case loads on the store attachment points. (By analyzing each sway brace and hook/lug, utilizing the sign convention of Figure 3, the worst case store inertial loads for each store attachment component are listed. See Figure 4. For example, for a left front sway brace, the worst case loading is when the store is accelerating forward (-NX), accelerating to the left (-NY), accelerating upward (+NZ), roll accelerating clockwise looking forward (-PHIDD), pitch accelerating nose up (+THEDD), and yaw accelerating nose left (+PSIDD).)

4. Worst case inertial loads are to be applied at the center of gravity, CG, of the store. The dimensions of the CG to the store attachment points are defined in Figure 5 and are described in Appendix A. From this a summation of the forces, Σ Fx=0, Σ Fy=0, Σ Fz=0 and summation of the moments Σ Mx=0, Σ My=0, Σ Mz=0 can be calculated. The results are the worst case loads at each component as a function of the store inertial accelerations.

The equations for the worst case load at the FORWARD SWAY BRACE are:

Vertical forward sway brace reaction;

$$SZFWD = A*PX + B*PY + C*PZ + D*MX + E*MY + F*MZ$$

where:

PX, *PY*, and *PZ* are the total forces (inertial and aerodynamic) in the X,Y, and Z directions respectively.

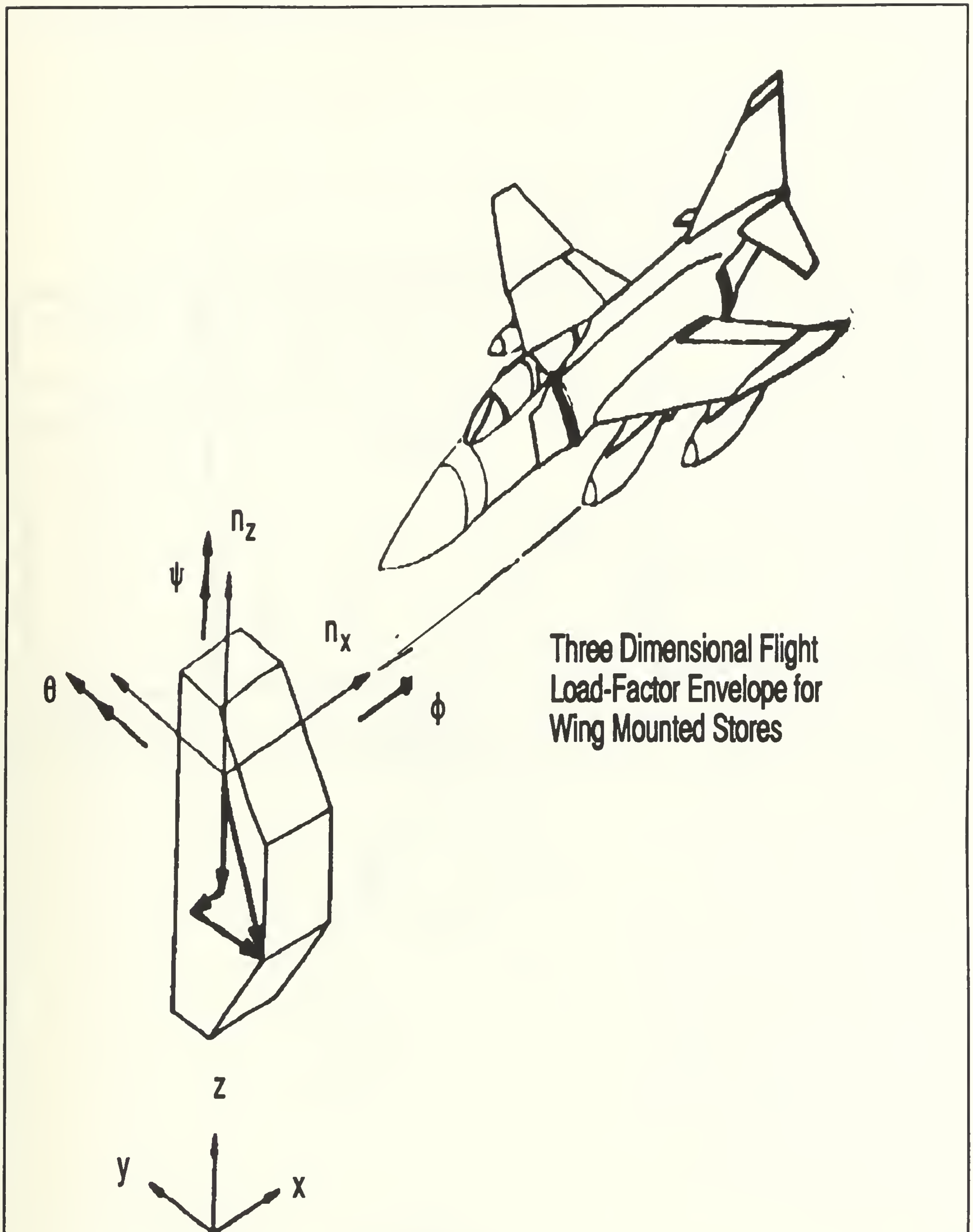


Figure 3. Coordinate System, Sign Convention, and a Typical Load Factor Envelope

Store Inertial Loads	SB/store SB pad				Hook/Lug	
	Fwd		Aft			
	L	R	L	R	F	R
N_x	-	-	+	+	+	-
N_y	-	+	-	+	±	±
N_z	+(1)	+(1)	+(1)	+(1)	-	-
$\ddot{\phi}$	-	+	-	+	±	±
$\ddot{\theta}$	+	+	-	-	-	±
$\ddot{\psi}$	+	-	-	+	±	±

NOTE: (1) If the CG of the store is located laterally outside of the SB's, a negative vertical load (P_z, down) may be critical and should be investigated.

Figure 4. Direction of External Loads and Moments for Maximum Reaction Forces at the SB's/Stores SB Pads and Hooks/Lugs

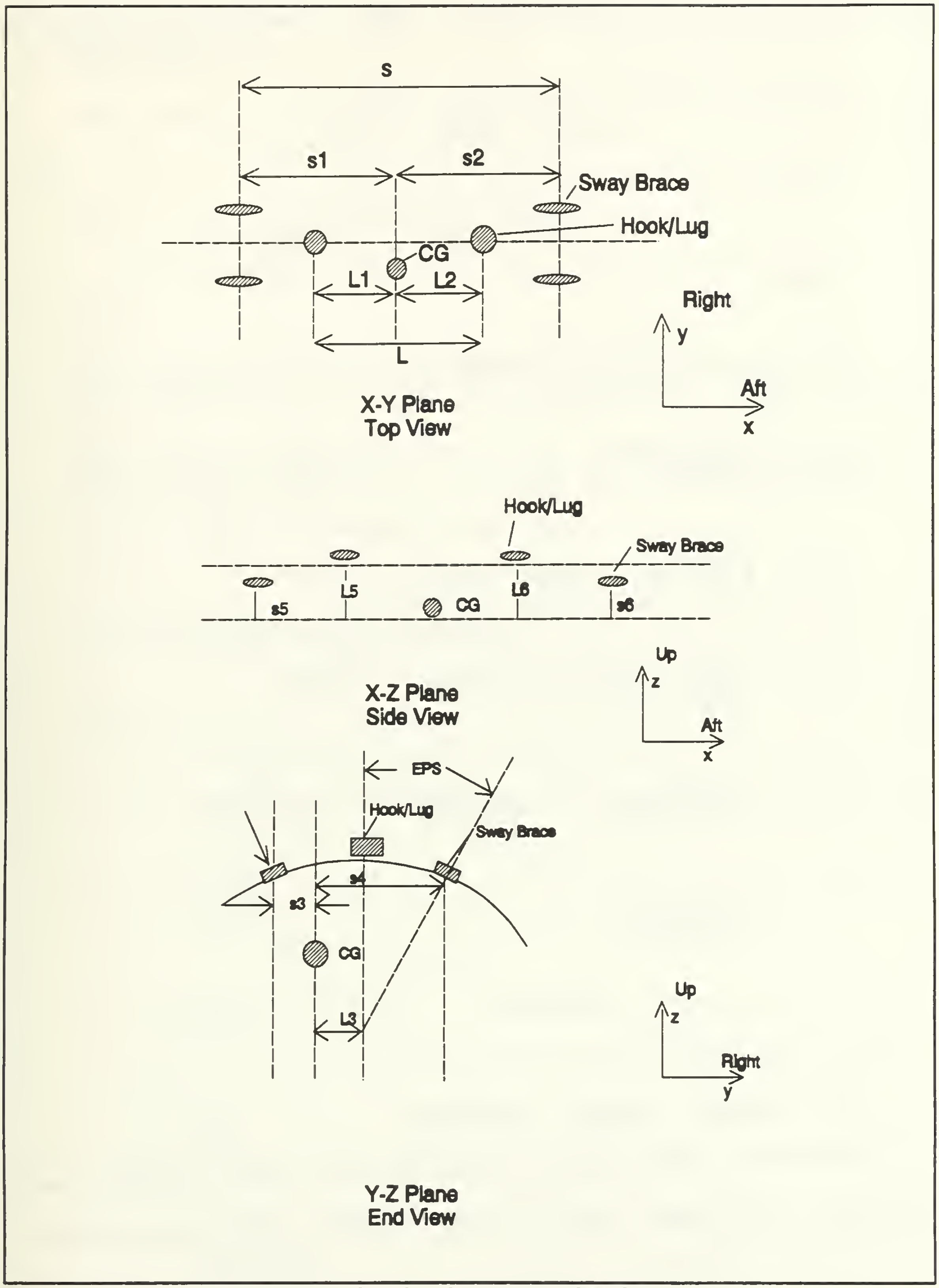


Figure 5. Store Physical Characteristics

MX, *MY*, and *MZ* are the total moments (inertial and aerodynamic) about the X, Y, and Z axis respectively.

Lateral forward sway brace reaction;

$$SYFWD = SZFWD * TAN(EPS)$$

Total forward sway brace reaction;

$$STOTFWD = SZFWD / COS(EPS)$$

where:

$$A = \frac{L5}{2\,(S1 + L2)} + \frac{L3}{S * TAN(EPS)}$$

$$B = \frac{S2 * L5}{S * K}$$

$$C = \left(\frac{S2}{S}\right) * \left(.5 + \frac{L3}{K}\right)$$

$$D = \frac{S2}{S * K}$$

$$E = \frac{.5}{(S1 + L2)}$$

$$F = \frac{1}{TAN(EPS)}$$

$$H = (L5 - S5) * TAN(EPS)$$

$$K = H + L3 + S3$$

note: $SZFWD^2 + SYFWD^2 = STOTFWD^2$

The worst case load for the left or right forward sway brace is the same due to the symmetry of the inertial envelopes and the fact that the stores are carried on the left or right wing.

The equations for the worst case load at the AFT SWAY BRACE are:

Vertical aft sway brace reaction;

$$SZAFT = A*PX + B*PY + C*PZ + D*MX + E*MY + F*MZ$$

where:

PX, PY, and *PZ* are the total forces (inertial and aerodynamic) in the X,Y, and Z directions respectively.

MX, MY, and *MZ* are the total moments (inertial and aerodynamic) about the X, Y, and Z axis respectively.

Lateral aft sway brace reaction;

$$SYAFT = SZAFT * TAN(EPS)$$

Total aft sway brace reaction;

$$STOTAFT = SZAFT \,/\, COS(EPS)$$

where:

$$A = \frac{L5}{2\,(S2 + L1)} + \frac{L3}{S * TAN(EPS)}$$

$$B = \frac{S1 * L5}{S * K}$$

$$C = \left(\frac{S1}{S}\right) * \left(.5 + \frac{L3}{K}\right)$$

$$D = \frac{S1}{S * K}$$

$$E = \frac{.5}{(S2 + L1)}$$

$$F = \frac{1}{S * TAN(EPS)}$$

$$H = (L5 - S5) * TAN(EPS)$$

$$K = H + L3 + S3$$

note: $SZAFT^2 + SYAFT^2 = STOTAFT^2$

The worst case load for the left or right aft sway brace is the same due to the symmetry of the inertial envelopes and the fact that the stores are carried on the left or right wing.

The equations for the worst case load at the FORWARD HOOK/LUG are:

Vertical forward hook/lug reaction;

$$LZFWD = AZ*PX + BZ*PY + CZ*PZ + DZ*MX + EZ*MY + FZ*MZ$$

Lateral forward hook/lug reaction;

$$LYFWD = BY*PY + CY*PZ + DY*MX$$

Longitudinal forward hook/lug reaction;

$$LXFWD = PX$$

Total forward hook/lug shear reaction;

$$LTOTFWD = (LYFWD^2 + LXFWD^2)^{1/2}$$

where:

PX, PY, and PZ are the total forces (inertial and aerodynamic) in the X,Y, and Z directions respectively.

MX, MY, and MZ are the total moments (inertial and aerodynamic) about the X, Y, and Z axis respectively.

where:

$$AZ = \frac{L5}{(S2 + L1)} + \frac{L3}{S * TAN(EPS)}$$

$$BZ = \frac{S2 * L5}{S * K}$$

$$CZ = \left(\frac{L2}{L}\right)\left(\frac{L3}{(H + S4 - L3)} + 1\right)$$

$$DZ = \frac{S2}{S * K}$$

$$EZ = \frac{1}{(S2 + L1)}$$

$$FZ = \frac{1}{S * TAN(EPS)}$$

$$AY = EY = FY = 0$$

$$BY = \left(\frac{S2}{S}\right)\left(\frac{L5 * TAN(EPS)}{K} - 1\right)$$

$$CY = \frac{L2 * L3 * TAN(EPS)}{L * (H + S4 - L3)}$$

$$DY = \frac{S2 * TAN(EPS)}{S * K}$$

$$H = (L5 - S5) * TAN(EPS)$$

$$K = H + L3 + S3$$

The equations for the worst case load at the AFT HOOK/LUG are:

Vertical aft hook/lug reaction;

$$LZAFT = AZ*PX + BZ*PY + CZ*PZ + DZ*MX + EZ*MY + FZ*MZ$$

Lateral aft hook/lug reaction;

$$LYAFT = BY*PY + CY*PZ + DY*MX$$

Longitudinal aft hook/lug reaction;

$$LXAFT = PX$$

Total aft hook/lug shear reaction;

$$LTOTAFT = (LYFWD^2 + LXFWD^2)^{1/2}$$

where:

PX, *PY*, and *PZ* are the total forces (inertial and aerodynamic) in the X,Y, and Z directions respectively.

MX, *MY*, and *MZ* are the total moments (inertial and aerodynamic) about the X, Y, and Z axis respectively.

where:

$$AZ = \frac{L5}{(S1 + L2)} + \frac{L3}{S * TAN(EPS)}$$

$$BZ = \frac{S1 * L5}{S * K}$$

$$CZ = \left(\frac{L1}{L}\right)\left(\frac{L3}{(H + S4 - L3)} + 1\right)$$

$$DZ = \frac{S1}{S * K}$$

$$EZ = \frac{1}{(S1 + L2)}$$

$$FZ = \frac{1}{S * TAN(EPS)}$$

AY = EY = FY = 0

$$BY = \left(\frac{S1}{S}\right)\left(\frac{L5 * TAN(EPS)}{K} - 1\right)$$

$$CY = \frac{L1 * L3 * TAN(EPS)}{L * (H + S4 - L3)}$$

$$DY = \frac{S1 * TAN(EPS)}{S * K}$$

For all the cases listed, the CG of the store is located between the sway braces laterally and between the hook/lugs longitudinally. If a store has a CG that does not satisfy either condition, alternate equations must be utilized for the coefficients C, CY, and CZ, see [Ref. 1]. The computer program incorporates the alternate equations in the calculation of the reaction forces automatically, when required.

The direction of the vertical acceleration (PZ) for a critical load on the sway braces can be positive or negative when the store CG is laterally outside the sway braces. <u>Therefore, both positive and negative vertical accelerations must be considered when determining the critical sway brace load with the store CG laterally outside the sway braces</u>.

To incorporate store aerodynamic loads into the analysis, the respective aerodynamic loads must be reduced to forces and moments at the store CG. If data is available from prior sources (i.e., from wind tunnel tests), the data can be entered directly. Most preliminary designs are not afforded this luxury and must estimate aerodynamic loads. Mil-A-8591H

[Ref. 1] provides a method to determine the store's maximum angle-of-attack and sideslip but does not provide any guidance on various aerodynamic coefficients. If coefficients are available, the analysis can be completed and the results can then be combined with the store's inertial loads. Hoerner [Refs. 6, 7] generated several generic aerodynamic analyses for different stores mounted on an aircraft. General values for the coefficient of lift, coefficient of side-force, coefficient of pitching moment and coefficient of yawing moment are provided and utilized in a current store loads analysis [Ref. 2].

The coefficients that are utilized in the Hoerner analysis resolve the aerodynamic forces and moments at the store CG. The maximum angle-of-attack and the maximum angle-of-sideslip are provided by Mil-A-8591H [Ref. 1]. Utilizing the aerodynamic analysis of [Refs. 2, 6, and 7] the store reference area is computed as the circular area consistent with the store radius. The reference length is entered directly. If the reference length is not available, a general length of 22 * store radius is recommended [Ref. 6]. Since most stores are symmetrical from a front view, Y-Z plane, the coefficient of lift slope is assumed to be equal to the coefficient of side-force slope, and the pitch moment coefficient slope is assumed to be equal to the yaw moment coefficient slope. Hoerner suggests values of .32 for the coefficient of lift slope and coefficient of side-force slope;

a value of .13 for the pitching and yawing moment coefficient; and a value of .3 for the coefficient of drag. The equations utilized in the computer program to calculate the aerodynamic forces and moments at the store CG are:

Aerodynamic forces in the respective direction;

PXA = *CD * QUE * SR*

PYA = *CG * ANGS * QUE * SR*

PZA = *C1 * ANGA * QUE * SR*

Aerodynamic moments about the respective axis;

AMXA = 0

AMYA = *C2 * ANGA * QUE * SR * LR*

AMZA = *C7 * ANGS * QUE * SR * LR*

where:

C1 = Lift coefficient slope (per degree)

C2 = Pitch moment coefficient (per degree)

C6 = Side force coefficient slope (per degree)

C7 = Yaw moment coefficient slope (per degree)

CD = Coefficient of drag

QUE = Dynamic pressure (lb/sq ft)

SR = Store reference area (sq ft)

LR = Store reference length (inches)

ANGA = Store angle-of-attack (degrees)

ANGS = Store angle-of-sideslip (degrees)

The aerodynamic forces and moments are simple linear rough estimates and do not take into account non-linearities or interaction of the aircraft with the store [Refs. 2, 6, and 7]. As the design progresses past the preliminary stage a more detailed airload analysis must be performed.

V. COMPUTER PROGRAM

A computer program to conduct an analysis of the loads at the aircraft-store interface in accordance with Mil-A-8591H, was written by the author and installed on the VAX/VMS Computer System, Advanced Computational Laboratory of Aeronautics and Astronautics Department, Naval Postgraduate School. The program is designed to be utilized by aero engineering graduate students in their aircraft design courses. The input can be interactive or batch. The interactive input is useful when running the program for the first time. The batch input is the most convenient when several runs are required or when the student requires a copy of their data input.

The program flow chart is depicted in Figure 6. The program consists of an input subroutine, an output subroutine, an inertial load subroutine, an airload subroutine, a subroutine to combine inertial loads and airloads, four subroutines to calculate the loads at the respective attachment points, and a subroutine to resolve the store coordinate system with the aircraft coordinate system (for stores mounted at an angle to the aircraft coordinate system).

Once the data is input to the program, the airloads (if applicable) on the store CG are calculated, and the inertial loads are calculated. The loads are then combined and the

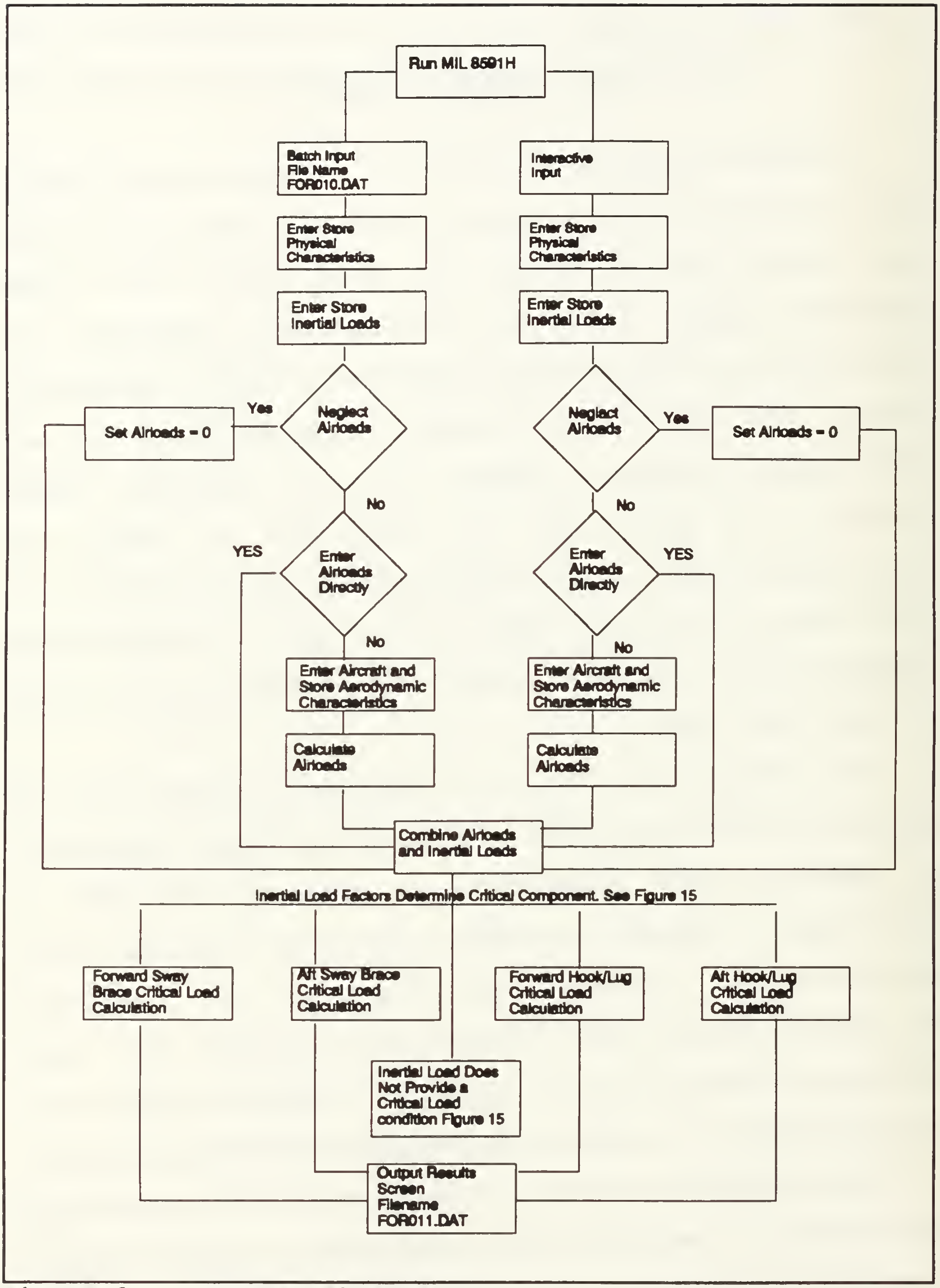


Figure 6. Program Flowchart

appropriate coordinate system is selected. The loading on the store is analyzed. The critical attachment component is determined and the appropriate set of equations are utilized to determine the worst case load on the appropriate store attachment component. The results are sent to the computer screen and an output file. The input and output data are available to the user until the program is run again. The files contain the data of the most recent run. If hard copies are desired they must be made before rerunning the program. Detailed instruction on using the program is provided in the Mil-A-8591H Users Manual, Appendix A of this text.

VI. RESULTS AND RECOMMENDATIONS

The program was tested against the sample problem in Mil-A-8591H, Appendix D [Ref. 1], of the specification. The sample consisted of a generic 2000 lb bomb analyzed with the general store inertial loading of Mil-A-8591H, Appendix A [Ref. 1]. The sample problem analyzed two inertial loading cases for the forward sway braces, two inertial loading cases for the aft sway braces, two inertial loading cases for the forward hook/lug, and two inertial loading cases for the aft hook/lug. The results of the computer program were identical to the results provided in the sample problem. The only difference is the specification sample problem used five significant figures while the computer program uses eight significant figures.

There was no airload analysis in the specification sample problem. The airload analysis in MIL-A-8591H is the same as the airload analysis in a current loads program [Ref. 2]. The inertial loads and airloads were combined and the resultant forces calculated. The effects of the airloads changed the resultant as expected. The program worked for all sample cases tested.

The program was successfully incorporated into the Naval Postgraduate School Aero Department VAX computer. The results show the data to be identical to the sample data generated in Mil-A-8591H, Appendix D [Ref. 1]. The computer code accomplishes the objective of this thesis, to provide an analysis of the aircraft-store interface reactions in accordance with Mil-A-8591H. The program will be useful as a design tool in aircraft, helicopter, and weapons design classes. Further testing and analysis of the program and methods incorporated in the program are required before this program is used in actual aircraft-store integration. This can be conducted, while the program is being used in aircraft, helicopter, and missile design courses at the Naval Postgraduate School.

Recommendations include comparing the results of the MIL-A-8591H loads program with a finite element analysis of a specific store. The results indicate the validity of the assumptions made in deriving the equations for the analysis.

The computer code can be made more efficient by creating a data base with all the store inertial envelopes of Mil-A-8591H [Ref. 1], to calculate loads for the entire inertial envelope. From this, worst case load conditions for each sway brace and hook/lug can be identified and printed out. This will eliminate input errors and the possibility of the user not choosing the critical envelope loading condition.

APPENDIX A: PROGRAM 8591H USER'S MANUAL

SECTIONS

I. INTRODUCTION

This user's manual describes how to apply a computer program (MIL8591H) to calculate reaction loads on aircraft-carried stores as recommended by military specification. The general design guide for aircraft store integration is Military Specification MIL-A-8591H, "Airborne Stores, Suspension Equipment And Aircraft-Store Interface (Carriage Phase); General Design Criteria For" [Ref. 1]. This specification outlines a method to calculate reaction loads for an aircraft suspension system equipment / store interface. A store is defined as any equipment that can be temporarily mounted to an aircraft wing or bomb bay pylon. Some common stores include weapons, auxiliary fuel tanks, electronic surveillance pods, electronic countermeasure pods, and gun pods. Weapons make up the majority of store types. Weapon suspension equipment is the interface of the store to the aircraft. Most stores are mounted to the aircraft by suspension equipment consisting of two hook/lug assemblies, and further secured by two sets of sway brace pads. A standard configuration is illustrated in Figure 7. The Aircraft Stores Interface Manuals (ASIM) Volumes 1-3 [Refs. 3, 4, and 5] provide detailed descriptions and engineering drawings of stores (Vol. 1), suspension equipment (Vol. 2), and aircraft

(Vol. 3). These references are currently utilized by the Department of Defense and NATO countries.

II. DESCRIPTION

The purpose of the MIL8591H program is to calculate the worst case load for each mounting interface (i.e., forward hook/lug, aft hook/lug, the four sway braces forward left, forward right, aft left, and aft right.) The program applies inertial and airloads to produce a net reaction at each attachment point. To successfully run the program three sets of information must be provided. The three major inputs are store/suspension equipment physical characteristics, inertial load factors and airload factors. A separate detailed section will be devoted to illustrate how to obtain this information. Figure 8 presented a flowchart that summarizes how the computer program works.

III. PHYSICAL CHARACTERISTICS

The major physical characteristics are the stores weight, mass moments of inertia, the distance of the store center of gravity to the hook/lugs and the distance of the center of gravity to the sway braces. For most current weapons and suspension equipment this information can be found in The Aircraft Stores Interface Manual (ASIM) Volumes 1-3; [Refs. 3, 4, and 5].

Weight of the store, which will be abbreviated W in the computer program, and the Mass Moments of Inertia, which will be abbreviated IX, IY, and IZ, can be obtained directly from Volume 1 of the ASIM Manual, Store Characteristics [Ref. 3]. The weight must be entered in units of pounds and the mass moments of inertia must be entered in units of slug-ft^2. Note that the program automatically converts the mass moments of inertia to units of lb-in-sec^2 during calculation to stay compatible with English (U.S.) units in the equations developed by the specification.

The distance of the center of gravity (CG) to the hook/lug and the distance of the center of gravity to the sway braces must be calculated. The first step is to directly read the distances from the CG to the hook/lugs using Volume 2 of the ASIM Manual, Store Characteristics [Ref. 4]. All distances are to be read in inches and as positive. The computer program uses only positive distances to calculate the loads. There are seven distances with respect to CG and hook/lug location that are of concern. The distances are referred to as inputs L, L1, L2, L3, L4, L5, and L6 (see Figures 9 and 10). The first input, the hook/lug spacing (L), is the distance from the forward store hook to the aft store hook. Inputs L1 and L2 are the longitudinal distances (x-direction) from the store CG to the forward hook/lug and to the aft hook/lug respectively. Inputs L3 and L4 are the lateral distance (y-direction) from the store CG to the forward and aft hook/lug respectively. The inputs L5 and L6 are the vertical (z-direction) distances from the store CG to the forward and aft hook/lug respectively. For most stores, L3 usually equals L4, and L5 equals L6 but caution should be exercised when dealing with non symmetric stores or stores mounted at an angle to the vertical. Figures 9 and 10 illustrate the store physical characteristics with respect to the hook/lug.

The distances of the CG to the sway braces are calculated using Volume 3 of the ASIM Manuals, Suspension Equipment [Ref. 5]. Detailed drawings of commonly used suspension equipment are presented. The problem is to relate the physical characteristics of the store to the physical characteristics of the suspension equipment. A point common to both the store and the suspension equipment is the hook/lug. By transforming the relation of the store CG with respect to the store lug to the suspension equipment drawing, the CG can be related to the suspension equipment hook and the distances from the CG to the sway braces can be obtained.

There are seven inputs with respect to CG and sway brace location that are required. The inputs are referred to as S, S1, S2, S3, S4, S5, and S6 (see Figures 9 and 10). The first input, the sway brace spacing (S), is the distance from the forward sway brace to the aft sway brace. The inputs S1 and S2 are the longitudinal distances (x-direction) from the CG to the forward sway brace and to the aft sway brace respectively. The inputs S3 and S4 are the lateral distances (y-direction) from the CG to the left and right sway brace respectively. The inputs S5 and S6 are the vertical (z-direction) distances from the CG to the forward and aft sway brace respectively. For most stores, S3 usually equals S4 and S5 equals S6, but caution should be exercised when dealing with non symmetric stores or stores mounted at an angle to the vertical. Figures 9 and 10 illustrate the store physical characteristics with respect to the sway braces.

The only other physical characteristics required to run the load analysis are the angle of the sway brace pads with respect to the vertical, designated (EPS) epsilon; and the angle of the mounted store with respect to the vertical, designated (DEL1) delta 1. Figure 10 illustrates both angles.

IV. INERTIAL LOADS

The inertial loads required for the analysis consist of six accelerations to the store's center of gravity. They are the longitudinal acceleration (Nx), lateral acceleration (Ny), vertical acceleration (Nz), roll angular acceleration (PHIDD), pitch angular acceleration (THEDD), and yaw angular acceleration (PSIDD). Note that PHIDD, THEDD,and PSIDD are short for phi double dot, theta double dot and psi double dot and correspond to the NASA notation for the angular acceleration of an air vehicle.

The coordinate system and sign convention (right hand coordinate system) utilized in the program is illustrated in Figure 11. The sign convention of the accelerations is an important consideration in the analysis of the problem. All the signs of angles and rates must be consistent with the positive coordinate system indicated, Figure 11. <u>An incorrect sign will invalidate the entire analysis.</u> The longitudinal axis (x-axis) is positive aft and roll acceleration is clockwise looking aft. The lateral axis (y-axis) is positive right looking down and the pitch acceleration is positive pitch nose up. The vertical axis (z-axis) is positive up and positive yaw acceleration is positive nose left looking forward.

General inertial envelopes are provided for tactical carrier based aircraft in Figures 12 and 13, and for helicopters in Figure 14. These inertial envelopes are to be utilized when no individual aircraft carriage is specified or when a broad spectrum of carriage aircraft are being considered. When more specific aircraft performance data is available the inertial envelopes can be adjusted accordingly with the consent of the acquiring activity. Mil-A-8591H, Appendix B [Ref. 1], can be utilized to give more specific envelopes. Since the analysis being conducted is for preliminary designs, the general envelopes will be utilized.

The inertial envelope for the tactical carrier aircraft Figure 12, contains envelopes for arrested landings, catapult take offs, and in-flight wing-mounted stores. A second in-flight inertial envelope is presented for wing-tip mounted stores. The inertial envelope for the tactical carrier aircraft Figure 13, contains envelopes for arrested landings, catapult take offs, and in-flight fuselage mounted stores. Notice that the wing mounted stores have the most severe inertial loading. The inertial envelopes in Figures 12, 13, and 14, are actually three dimensional envelopes, since there is a plus/minus g factor listed with the angular accelerations.

To utilize the computer program, a worst case inertial loading must be determined. The worst case inertial loadings will be found at the "corners" of the inertial envelopes. Mil-

A-8591H, Appendix D [Ref. 1], describes a procedure to determine the worst case load for each suspension equipment component (i.e. hook/lug or sway brace). By assuming that the hook/lug can only take a tensile load and the sway braces can only take a compressive load the direction of the worst case inertial loading is presented in Figure 15. For example, the worst case inertial condition for the forward left sway brace is when there is a negative x acceleration, a negative y acceleration, a positive z acceleration, a negative x angular acceleration (roll), a positive y angular acceleration (pitch), and positive z angular acceleration (yaw). Note that the sign conventions of Figure 11 must be adhered to for a valid computer analysis. Once the direction of the worst case inertial loads are determined, the magnitudes are obtained from the envelopes depicted in Figures 12 and 13. The computer program automatically indicates to the user the component that will experience the worst load when an inertial loading condition is applied.

To utilize the analysis for a helicopter, the directions of the acceleration are determined by Figure 15 while the magnitudes of the acceleration are determined by Figure 14. The inertial envelope produced in Figure 14 is a generic envelope, calculated using generic data from the equations of Mil-H-8591H, Appendix C [Ref. 1]. The inertial load envelopes of Figure 14 are only for preliminary design. Specification compliance with this specific helicopter inertial load envelope is not mandated but requires the approval of the acquiring activity.

The reaction loads at the store interface are equal and opposite for the store and the suspension equipment, therefore the analysis can be used for preliminary store or aircraft design.

V. AIRLOADS

Airloads are probably the most difficult forces to determine in the analysis. There are three options available to determine the airloads on the store. The first option is to simply ignore the airloads. This is not a bad approximation for arrested landings and catapult takeoffs, but it is not realistic for in-flight data for high performance aircraft. The second option is to directly input the airloads (if available) from experimental data or wind tunnel modeling. Although a best estimate, this data is usually not available in the preliminary design stage. The third method is to calculate the airloads from the data available with respect to maximum angles of attack, and maximum angle-of-sideslip.

Mil-A-8591H, Appendix A [Ref. 1], provides equations to calculate the maximum angle-of-attack and the maximum angle-of-sideslip for very specific flight maneuvers (i.e., pushovers, and pullups) at specific corners of the inertial flight envelope. The maximum angle-of-attack for the store (ANGA) and the maximum angle-of-sideslip (ANGS) are functions of dynamic pressure and flight maneuver and can be calculated from Figure 16 for wing mounted stores and Figure 17 for fuselage mounted stores. The slope of the lift coefficient, slope of the pitching moment coefficient, slope of the side force coefficient, and coefficient of drag must also be available to perform the airload analysis. Frequently, these data are not available for a preliminary design. The method presently applied [Ref. 2] models the store as a simple cylinder (most stores are) and uses generic coefficients to make an approximate of the airloads [Refs. 6, 7]. The computer program uses this option as a default (model the store as a simple cylinder) capability. See the sample problem for implementation of the airload default capability.

Computation of airloads for helicopters is not addressed in the specification. The recommended method of helicopter airload analysis (i.e., wind tunnel analysis or rotor flight simulation programs) is beyond the preliminary design phase. Considering the lower airspeed that helicopters fly, the initial estimate of airloads with respect to inertial loads is not as critical. Unless the airloads of a store are available, the next best option is to estimate the airloads during the preliminary design stage.

VI. ASSUMPTIONS AND LIMITATIONS

Due to the fact that the store is a statically indeterminate structure with unknown flexibility characteristics, the analysis to calculate the reaction on the store suspension equipment is a relatively complex problem. By making several assumptions, the problem can be simplified so a general analysis can be performed for stores and aircraft that are still in the preliminary design stage.

The analysis covered in this program assumes that the store is a rigid body. Other assumptions are: the loads at the hook/lug are tensile only, and the loads at the sway brace pads are compressive only; the sway braces are usually at a roll angle to the store and can exert a lateral and vertical force, but cannot exert a longitudinal force. Since designers are concerned with worst case loads the equations are derived using the external load conditions of Figure 15. These external loads provide the maximum reaction forces at each individual hook/lug and sway brace as indicated. The result of these assumptions simplifies the problem to a statically determinate problem. The analysis includes both inertial and airloads. Other contributions to load factors such as flutter, rotor down wash, modal coupling, are beyond the scope of this analysis and beyond the scope of the preliminary design stage, but must be addressed during the detail design stage and before the critical design review (CDR).

VII. UTILIZING THE PROGRAM

The MIL8591H fortran computer program is installed on the VAX/VMS Computer System, Advanced Computational Laboratory of Aeronautics & Astronautics Department, Naval Postgraduate School. The program consists basically of three parts; input file, output file, and program code. The input file is called "for010.dat", the output file is called "for011.dat", and the program code is called "Mil8591H.for".

A description and implementation of the files is described in the following paragraphs.

VIII. INPUT DATA

The first step toward executing the program is to input the data. Data input can be either interactive or by a batch input file. The interactive data input is self explanatory but time consuming when multiple runs are required. A batch file is efficient to run several design cases. A hard copy of the batch input file could also be printed for later study. A first run with interactive is recommended, but once the user becomes familiar with the program, batch inputs are more convenient and efficient.

To demonstrate the execution of the program, a batch file will be created. For the program to work, the batch input file must be named, for010.dat. The batch input file will already exist in the computer and will look like the following:

```
STORE CG POSITION WITH RESPECT TO SWAY BRACE PADS.
1
STORE CG POSITION WITH RESPECT TO HOOK/LUGS.
1
STORE WEIGHT (W) LBS
1000
STORE MOMENT OF INERTIA X-AXIS (IX) SLUG-FT**2
4.8
STORE MOMENT OF INERTIA Y-AXIS (IY) SLUG-FT**2
106.0
STORE MOMENT OF INERTIA Z-AXIS (IZ) SLUG-FT**2
106.0
DISTANCE BETWEEN FOR AND AFT SWAY BRACE PADS (S) IN
18
DISTANCE BETWEEN CG AND FOR SWAY BRACE PADS X-DIRECTION (S1)
IN.
9
```

```
DISTANCE BETWEEN CG AND AFT SWAY BRACE PADS X-DIRECTION (S2)
IN.
9
DISTANCE BETWEEN CG AND NEAR SWAY BRACE PADS Y-DIRECTION (S3)
IN.
3.2
DISTANCE BETWEEN CG AND FAR SWAY BRACE PADS Y-DIRECTION (S4)
IN.
3.2
DISTANCE BETWEEN CG AND RIGHT SWAY BRACE PADS Z-DIRECTION (S5)
IN.
6.0
DISTANCE BETWEEN CG AND LEFT SWAY BRACE PADS Z-DIRECTION (S6)
IN.
6.0
DISTANCE BETWEEN FOR AND AFT LUGS X-DIRECTION (L) IN.
14
DISTANCE BETWEEN CG AND FWD LUG X-DIRECTION (L1) IN.
7
DISTANCE BETWEEN CG AND AFT LUG X-DIRECTION (L2) IN.
7
DISTANCE BETWEEN CG AND FWD LUG Y-DIRECTION (L3) IN.
0
DISTANCE BETWEEN CG AND AFT LUG Y-DIRECTION (L4) IN.
0
DISTANCE BETWEEN CG AND FWD LUG Z-DIRECTION (L5) IN.
7.5
DISTANCE BETWEEN CG AND AFT LUG Z-DIRECTION (L6) IN.
7.5
EXTERNAL LOAD FACTOR X-DIRECTION (NX).
-1.5
EXTERNAL LOAD FACTOR Y-DIRECTION (NY).
-5
EXTERNAL LOAD FACTOR Z-DIRECTION (NZ).
-12
EXTERNAL ANGULAR ACCELERATION X-DIRECTION (PHIDD) RAD/SEC^2.
0
EXTERNAL ANGULAR ACCELERATION Y-DIRECTION (THEDD) RAD/SEC^2.
-4
EXTERNAL ANGULAR ACCELERATION Z-DIRECTION (PSIDD) RAD/SEC^2.
-2
ANGLE BETWEEN RADIUS OF CURVATURE OF STORE AND Z-AXIS (EPS)
DEG.
20
THE ROLL ANGLE BETWEEN THE AIRCRAFT AND THE STORE (DEL1) DEG.
0
HOW AirloadS ARE TO BE ANALYZED. ENTER OPTION 1,2,OR 3.
3
C* IF THE AIRLOADS ARE NEGLECTED OPTION 1 DO NOT ENTER ANY
FURTHER DATA
```

```
C* IF THE AIRLOADS ARE TO BE ANALYZED (I.E. OPTION 2 OR 3
selected)
C* OPTION 2 THE FOLLOWING 6 LINES MUST BE ENTERED
C* OPTION 3 THE LAST 12 LINES MUST BE ENTERED
C*
C* INPUT AIRLOADS DIRECTLY FROM WIND TUNNEL DATA OPTION 2
C*
LONGITUDINAL AIRLOAD (PXA) LB X-DIRECTION POSITIVE AFT
0
LATERAL AIRLOAD (PYA) LB Y-DIRECTION POSITIVE LEFT
0
VERTICAL AIRLOAD (PZA) LB Z-DIRECTION POSITIVE UP
0
ROLL MOMENT- ROLL (AMXA) IN-LB POSITIVE CCW LOOKING FORWARD
0
PITCH MOMENT- PITCH (AMYA) IN-LB POSITIVE NOSE UP
0
YAW MOMENT- YAW (AMZA) IN-LB POSITIVE NOSE LEFT
0
C*
C* INPUT DATA TO CALCULATE AIRLOADS OPTION 3
C*
AIRCRAFT VELOCITY (VEL) - FT/SEC
600
ANGLE OF ATTACK (ANGA) - DEG
76
ANGLE OF SIDE-SLIP (ANGS) - DEG
6
AIR DENSITY (DEN) - SLUG/CUBIC FT
.000278
REFERENCE RADIUS (R)- IN
8
C* WRITE STORE AERODYNAMIC CHARACTERISTICS (FOR UNKNOWN
VALUES,
C* ENTER A "0" AND DEFAULT VALUES BASED ON A CYLINDRICAL
C* SHAPE WILL BE ENTERED
REFERENCE AREA (SR) - FT-SQ
0
REFERENCE LENGTH (LR) - IN
0
STORE LIFT COEFFICIENT SLOPE (C1) - PER DEG
0
STORE PITCH MOMENT COEFFICIENT SLOPE (C2) - PER DEG
0
STORE SIDE-FORCE COEFFICIENT SLOPE (C6) - PER DEG
0
STORE YAW MOMENT COEFFICIENT SLOPE (C7) - PER DEG
0
```

STORE DRAG COEFFICIENT (CD)
0

The general format of the input file must remain as it is, only the input of numerical values can be changed. If comment lines are deleted or altered, it may not allow the program to run.

The batch input file inputs "STORE CG POSITION WITH RESPECT TO SWAY BRACE PADS," "STORE POSITION WITH RESPECT TO HOOK/LUGS," and "HOW ARE THE AIRLOADS TO BE ANALYZED" need explanation. All other inputs are self explanatory.

The input "STORE CG POSITION WITH RESPECT TO SWAY BRACE PADS" requires a number from 1 to 7 to be entered. The following cases represent the options available.

1. The store CG is between the sway braces longitudinally and laterally.

2. The store CG is between the sway brace pads longitudinally but outside the sway brace pads laterally.

3. The store CG is forward of the front sway brace pad longitudinally but between the sway brace pads laterally.

4. The store CG is forward of the front sway brace pad longitudinally but outside the sway brace pads laterally.

5. The store CG is between the sway brace pads longitudinally but outside the sway brace pads laterally.

6. The store CG is aft of the rear sway brace pad longitudinally but between the sway brace pads laterally.

7. The store CG is aft of the rear sway brace pad longitudinally but outside the sway brace pads laterally.

The large majority of stores fits into category 1 with the store CG located between the sway braces longitudinally and laterally.

The input "STORE CG POSITION WITH RESPECT TO HOOK/LUGS" requires a number from 1 to 3 to be entered. The following cases represent the options available.

1. The store CG is between the hook/lugs.
2. The store CG is in front of the forward hook/lug.
3. The store CG is aft of the rear hook/lug.

The large majority of stores fits into category 1 with the store CG located between the hook/lugs.

The input "HOW ARE THE AIRLOADS TO BE ANALYZED" requires a number from 1 to 3 to be entered. The following cases represent the options available.

1. Neglect the airloads (i.e. arrested landing, catapult takeoff)
2. Input airloads directly from wind tunnel data.
3. Calculate airloads.

Option 1 neglects the airloads and assigns values of zero for the longitudinal, lateral, and vertical airloads. The aerodynamic roll pitch and yaw moment are also assigned a value of zero. Option 1 would be used when an analysis of only inertial loads are required as in arrested landings or catapult takeoffs. If Option 1 is entered the program stops reading the input file at that data point and proceeds with calculations. The results display the zero airload condition.

Option 2 allows the user to directly input airloads and aerodynamic moments obtained by other methods such as wind tunnel data or data from similar stores. If Option 2 is entered the six data points PXA (longitudinal airload), PYA (lateral airload), PZA (vertical airload), AMXA (aerodynamic roll moment), AMYA (aerodynamic pitch moment), and AMZA (aerodynamic yaw moment) will be read into the program and combined with the inertial loads to calculate the net reaction forces at the critical sway brace or hook/lug. The output will display the aerodynamic loads and moments.

Option 3 will calculate the aerodynamic loads and moments. There are 12 inputs required to calculate the loads and moments. The inputs VEL (aircraft velocity), ANGA (store angle of attack), ANGS (store angle of sideslip), DEN (air density), and R(store reference radius) must be entered, since no default values are available for these five inputs. The maximum angle-of-attack for the store (ANGA) and the maximum angle-of-sideslip (ANGS) are functions of dynamic pressure and flight maneuver and can be calculated from Figure 16 for wing mounted stores and Figure 17 for fuselage mounted stores. The final six inputs; SR (reference area), LR (reference length), C1 (store lift coefficient slope), C2 (store pitch coefficient slope), C6 (store side-force coefficient slope), C7 (store yaw moment coefficient slope), can be entered directly if the values are known or a zero can be entered and default values based on a cylindrical shape will be utilized in the calculation of the aerodynamic forces and moments. The airload analysis based on the cylindrical shape [Refs. 6 and 7] is utilized in a current MIL-A-8591 loads analysis [Ref. 2]. The output will display the aerodynamic loads and moments used in calculation of the reaction forces on the store.

IX. RUNNING THE PROGRAM

Assuming the user logged on to the computer and edited the input file for010.dat with the desired inputs simply type;

run mil8591h

The program will prompt the following;

ENTER 1 FOR INTERACTIVE 2 FOR BATCH IO

Enter the desired number and the program will continue. If you run interactive you will enter the same data, one line at a time, as in the batch input file. Once the data is read, the program automatically runs and output data is displayed on the screen and saved in output data file, for011.dat. To obtain a hard copy of the input file and/or the output file print the appropriate file. For example on the NPGS AERO DEPARTMENT VAX:

To obtain a hard copy of the input file type;

print for010.dat/que=ln03

To obtain a hard copy of the output file type;

print for011.dat/que=ln03

The input file will look like the example in the input section of this manual and the output file will look like the example in the output section of this manual. If hard copies are desired they must be made prior to rerunning the program. The input and output file contain only the latest data i.e., the input and output files are updated with each run. To run the program again, edit the input file, for010.dat, with the desired changes in conditions and type run mil8591h. A new input and output file will be created with the latest data.

X. OUTPUT FILE

The output data will indicate which component (lug or sway brace) experiences the worst case load. The magnitude of the loads for the indicated directions will be presented. Remember the hook/lugs can only react in tension and the sway braces can only react in compression. The sway braces cannot react a load in the longitudinal or x-direction. The inertial loads and airloads applied in the analysis are presented. The major physical characteristics, weight and mass moments of inertia are indicated, and finally the data utilized to compute the airloads, if applicable, are presented. Since physical characteristics usually remain constant for a store, a record of analysis for a particular store would consist of one input file attached to the multiple output files.

The actual output file for the data represented in the input section of this manual will look like the following;

```
WORST CASE LOAD IS AT THE AFT HOOK

    AFT HOOK/LUG LOADS LBS
VERTICAL       =  18977.46
LATERAL        =  659.9890
LONGITUDINAL   =  1290.393
TOTAL SHEAR    =  1449.379


       **INERTIAL LOADS APPLIED**
    LOAD FACTOR G"S              ANGULAR ACCELERATION RAD/SEC**2
LONGITUDINAL   =  -1.500000   ROLL     =   0.0000000E+00
LATERAL        =  -5.000000   PITCH    =   -4.000000
VERTICAL       =  -12.00000   YAW      =   -2.000000
```

```
       **AERODYNAMIC LOADS APPLIED**
    AIRLOAD LB                      AERODYNAMIC MOMENT IN-LB
LONGITUDINAL   =   209.6069    ROLL     =   0.0000000E+00
LATERAL        =   134.1484    PITCH    =   121493.8
VERTICAL       =   1699.214    YAW      =   9591.612


STORE WEIGHT LBS =  2000.000
MASS MOMENT OF INERTIA X-AXIS LB-IN-SEC^2 = 57.60000
MASS MOMENT OF INERTIA Y-AXIS LB-IN-SEC^2 = 1272.000
MASS MOMENT OF INERTIA Z-AXIS LB-IN-SEC^2 = 1272.000


HOOK/LUG SPACING IN. =  14.00000
THE STORE CG IS  7.00000  IN FROM THE FWD HOOK/LUG

LONGITUDINAL SWAY BRACE SPACING IN =  18.00000
THE STORE CG IS  9.00000  IN FROM THE FWD SWAY BRACE

AIRLOADS WERE CALCULATED CASE 3

AIRCRAFT VELOCITY FT/SEC   =  600.0000
STORE ANGLE OF ATTACK DEG  =  76.00000
STORE ANGLE OF SIDESLIP DEG =  6.000000
```

XI. SAMPLE PROBLEM

The purpose of the sample problem is to demonstrate application of the computer program for a generic store and generic suspension equipment (i.e., bomb and bomb rack). The sample configuration is depicted in Figure 18. The necessary dimensions to run the program are indicated. The computer program can be utilized either interactively or by a batch input. If multiple iterations are to be analyzed, it is recommended to use the batch input. Results are provided on the user's screen and the results are recorded in an output file so a hard copy can be produced. A summary of changes to the input file with a summary of the resulting changes in the output file will illustrate execution of the problem. The details of operating the computer are in the section of this manual on the running the program.

The analysis is accomplished using three steps. The first step is to enter the physical characteristics into the input file.

The second step is to input an inertial load from the appropriate inertial envelope Figures 12, 13, or 14, and critical load Figure 15. Rerun the program with different inertial load conditions until you are satisfied you have the most critical case. The third step is to apply the appropriate airloads to the most critical *<u>inflight</u>* inertial load condition. By comparing the catapult, arrested, and in-flight (with airloads) cases, the worst case load can be identified.

The physical characteristics of the store and suspension equipment are illustrated in Figures 9 and 18. Edit the input file FOR010.DAT and replace the appropriate data. The respective input file is depicted in the input section of this manual. Enter the inertial load condition and initially select "1" (neglect airloads) under the "HOW DO YOU WANT THE AIRLOADS ANALYZED" input.

This allows the user to find the worst case inertial load. After the worst case inertial loads are calculated, add airloads to the in-flight case by rerunning the program with a "2" or "3" entered under the "HOW DO YOU WANT THE AIRLOADS ANALYZED" input. The appropriate aerodynamic data must also be entered.

A. FRONT SWAY BRACE

In this example we analyze the left front sway brace for a wing mounted store on a carrier based aircraft. From Figure 15 the critical store inertial load for the left front sway brace is -NX, -NY, +NZ, -PHIDD, +THEDD, and +PSIDD. The envelope in Figure 12 is utilized for wing mounted stores on a carrier based aircraft to find the magnitudes at the worst case. In this example there are several possibilities for a worst case (corners of the envelope) loading.

Remember to keep sign conventions consistent as indicated.

	NX	NY	NZ	$\ddot{\phi}$	$\ddot{\theta}$	$\ddot{\psi}$	ENVELOPE
CASE 1:	-9	-5	+2	-100	+25	+6	ARRESTED LANDING
CASE 2:	-3	-5	+4	-100	+25	+6	ARRESTED LANDING
CASE 3:	-1.5	-1.5	+7	0	+4	+2	FLIGHT

By running the program with these store inertial loads the results for the forward left sway brace are;

	Sz (lbs)	Sy(lbs)	Stot(lbs)	ENVELOPE
CASE 1:	10542	3837	11218	ARRESTED LANDING
CASE 2:	9636	3507	10254	ARRESTED LANDING
CASE 3:	4150	1510	4416	FLIGHT

Now CASE 3 must be analyzed with airloads added. Since the component is the left forward sway brace, the critical airloads will be in the positive vertical (z-direction), negative lateral (y-direction), positive store pitch moment (nose up), and positive store yaw moment (nose left). If option 2 for analyzing the airloads is selected the data is entered with the sign and magnitude under the appropriate entry.

If option 3 is selected, Figure 16 is utilized to find the largest angle-of-attack and largest angle-of-sideslip to produce the desired airload signs. In this example a positive angle-of-attack and positive angle-of-sideslip will produce the critical airloads. To find the magnitude of these angles, assume that the aircraft is travelling at 600 ft/sec at an air density of .00278 slugs/ft^2. Using the equation for point 4 (the in-flight inertial point of CASE 3), the maximum angle-of-attack is 0 degrees and maximum angle-of-sideslip is +6 degrees. Enter the inputs into the input file (in this example enter default values "0" for the coefficient slopes) and rerun the program. The result for CASE 3 with airloads is 5779 lbs. The worst case load for the left front sway brace is CASE 1 ARRESTED LANDING.

The worst case load for the right front sway brace is the same as the left front sway brace, since the magnitudes of the angular accelerations are equal in the positive and negative direction. The store can be mounted on the left or right wing causing the in-flight envelope, Figures 12 and 13, to be symmetric.

B. AFT SWAY BRACE

In this example we analyze the left aft sway brace for a wing mounted store on a carrier based aircraft. From Figure 15 the critical store inertial load for the left front sway brace is +NX, -NY, +NZ, -PHIDD, -THEDD, -PSIDD. The envelope in Figure 12 is utilized for wing mounted stores on a carrier based aircraft to find the magnitudes at the worst case. In this example there are several possibilities for a worst case (corners of the envelope) loading.

Remember to keep sign conventions consistent as indicated.

	NX	NY	NZ	$\ddot{\phi}$	$\ddot{\theta}$	$\ddot{\psi}$	ENVELOPE
CASE 1:	+9	-2.5	+1.5	-25	-15	-4	CATAPULT T/O
CASE 2:	+2	-5	+4	-100	-25	-6	ARRESTED LANDING
CASE 3:	+1.5	-1.5	+7	0	-4	-2	FLIGHT

By running the program with these store inertial loads the results for the aft left sway brace are;

	Sz (lbs)	Sy(lbs)	Stot(lbs)	ENVELOPE
CASE 1:	6552	2385	6973	CATAPULT T/O
CASE 2:	9401	3421	10005	ARRESTED LANDING
CASE 3:	4150	1510	4416	FLIGHT

Now CASE 3 must be analyzed with airloads added. Since the component is the left aft sway brace, the critical airloads will be in the positive vertical (z-direction), negative lateral (y-direction), negative store pitch moment (nose down), and negative store yaw moment (nose right). If option 2 for analyzing the airloads is selected, the data is entered with the sign and magnitude under the appropriate entry.

If option 3 is selected, Figure 16 is utilized to find the largest angle-of-attack and largest angle-of-sideslip to produce the desired airload signs. In this example a negative angle-of-attack and negative angle-of-sideslip will produce the critical airloads. To find the magnitude of these angles, assume that the aircraft is travelling at 600 ft/sec at an air density of .00278 slugs/ft^2. Using the equation for point 4 (the in-flight inertial point of CASE 3) maximum negative angle-of-attack is -45 degrees and maximum negative angle-of-sideslip is -6 degrees. Enter the inputs into the input file (in this example enter default values "0" for the coefficient slopes) and rerun the program. The results for CASE 3 with airloads is 8294 lbs. The worst case load for the left front sway brace is CASE 2 ARRESTED LANDING.

The worst case load for the right aft sway brace is the same as the left aft sway brace since the magnitudes of the angular accelerations are equal in the positive and negative direction. The store can be mounted on the left or right wing causing the inflight envelope, Figures 12 and 13, to be symmetric.

C. FORWARD HOOK/LUG

In this example we analyze the forward hook/lug for a wing mounted store on a carrier based aircraft. From Figure 15 the critical store inertial load for the forward hook/lug is +NX, ±NY, -NZ, ±PHIDD, -THEDD, ±PSIDD. The envelope in Figure 12 is utilized for wing mounted stores on a carrier-based aircraft to find the magnitudes at the worst case. In this example there are several possibilities for a worst case (corners of the envelope) loading.

Remember to keep sign conventions consistent as indicated.

	NX	NY	NZ	$\ddot{\phi}$	$\ddot{\theta}$	$\ddot{\psi}$	ENVELOPE
CASE 1:	+9	-2.5	-5	-25	-15	-4	CATAPULT T/O
CASE 2:	+2	-5	-12	-100	-25	-6	ARRESTED LANDING
CASE 3:	+1.5	-5	-12	0	-4	-2	FLIGHT

By running the program with these store inertial loads the results for the forward hook/lug are;

	Lz (lbs)	Lx(lbs)	Ly(lbs)	Lshear(lbs)	ENVELOPE
CASE 1:	11382	9000	409	9009	CATAPULT T/O
CASE 2:	15864	2000	958	2218	ARRESTED LANDING
CASE 3:	12414	1500	678	1646	FLIGHT

Now CASE 3 must be analyzed with airloads added. Since the component is the left aft sway brace the critical airloads will be in the negative vertical (z-direction), negative lateral (y-direction), negative store pitch moment (nose down), and negative store yaw moment (nose right). If option

2 for analyzing the airloads is selected, the data is entered with the sign and magnitude under the appropriate entry.

If option 3 is selected, Figure 16 is utilized to find the largest angle-of-attack and largest angle-of-sideslip to produce the desired airload signs. In this example a negative angle-of-attack and negative angle-of-sideslip will produce the critical airloads. To find the magnitude of these angles, assume that the aircraft is travelling at 600 ft/sec at an air density of .00278 slugs/ft^2. Using the equation for point 2 (the inflight inertial point of CASE 3) maximum negative angle-of-attack is 0 degrees and maximum angle-of-sideslip is +6 degrees. Enter the inputs into the input file (in this example enter default values "0" for the coefficient slopes) and rerun the program. The results for CASE 3 with airloads is 14111 lbs. The worst case load for the forward hook/lug is CASE 2 ARRESTED LANDING.

D. AFT HOOK/LUG

In this example we analyze the aft hook/lug for a wing mounted store on a carrier based aircraft. From Figure 15 the critical store inertial load for the aft hook/lug is -NX, ±NY, -NZ, ±PHIDD, ±THEDD, ±PSIDD. The envelope in Figure 12 is utilized for wing mounted stores on a carrier based aircraft to find the magnitudes at the worst case. In this example there are several possibilities for a worst case (corners of the envelope) loading.

Remember to keep sign conventions consistent as indicated.

	NX	NY	NZ	$\ddot{\phi}$	$\ddot{\theta}$	$\ddot{\psi}$	ENVELOPE
CASE 1:	-3	-5	-12	-100	-25	-6	ARRESTED LANDING
CASE 2:	-9	-5	-6	-100	-25	-6	ARRESTED LANDING
CASE 3:	-1.5	-5	-12	0	-4	-2	FLIGHT

By running the program with these store inertial loads the results for the forward hook/lug are;

	Lz (lbs)	Lx(lbs)	Ly(lbs)	Lshear(lbs)	ENVELOPE
CASE 1:	16332	3000	958	3149	ARRESTED LANDING
CASE 2:	16145	9000	958	9050	ARRESTED LANDING
CASE 3:	12414	1500	678	1646	FLIGHT

Now CASE 3 must be analyzed with airloads added. Since the component is the left aft sway brace the critical airloads will be in the negative vertical (z-direction), negative lateral (y-direction), positive store pitch moment (nose up), and negative store yaw moment (nose right). If option 2 for analyzing the airloads is selected the data is entered with the sign and magnitude under the appropriate entry.

If option 3 is selected, Figure 16 is utilized to find the largest angl-of-attack and largest angle-of-sideslip to produce the desired airload signs. In this example a positive angle-of-attack and negative angle-of-sideslip will produce the critical airloads. To find the magnitude of these angles, assume that the aircraft is travelling at 600 ft/sec at an air density of .00278 slugs/ft^2. Using the equation for point 2 (the inflight inertial point of CASE 3) maximum positive angle-of-attack is 76 degrees and maximum angle-of-sideslip is +6 degrees. Enter the inputs into the input file (in this example enter default values "0" for the coefficient slopes) and rerun the program. The results for CASE 3 with airloads is 18977 lbs. The worst case load for the aft hook/lug is CASE 3 FLIGHT WITH AIRLOADS.

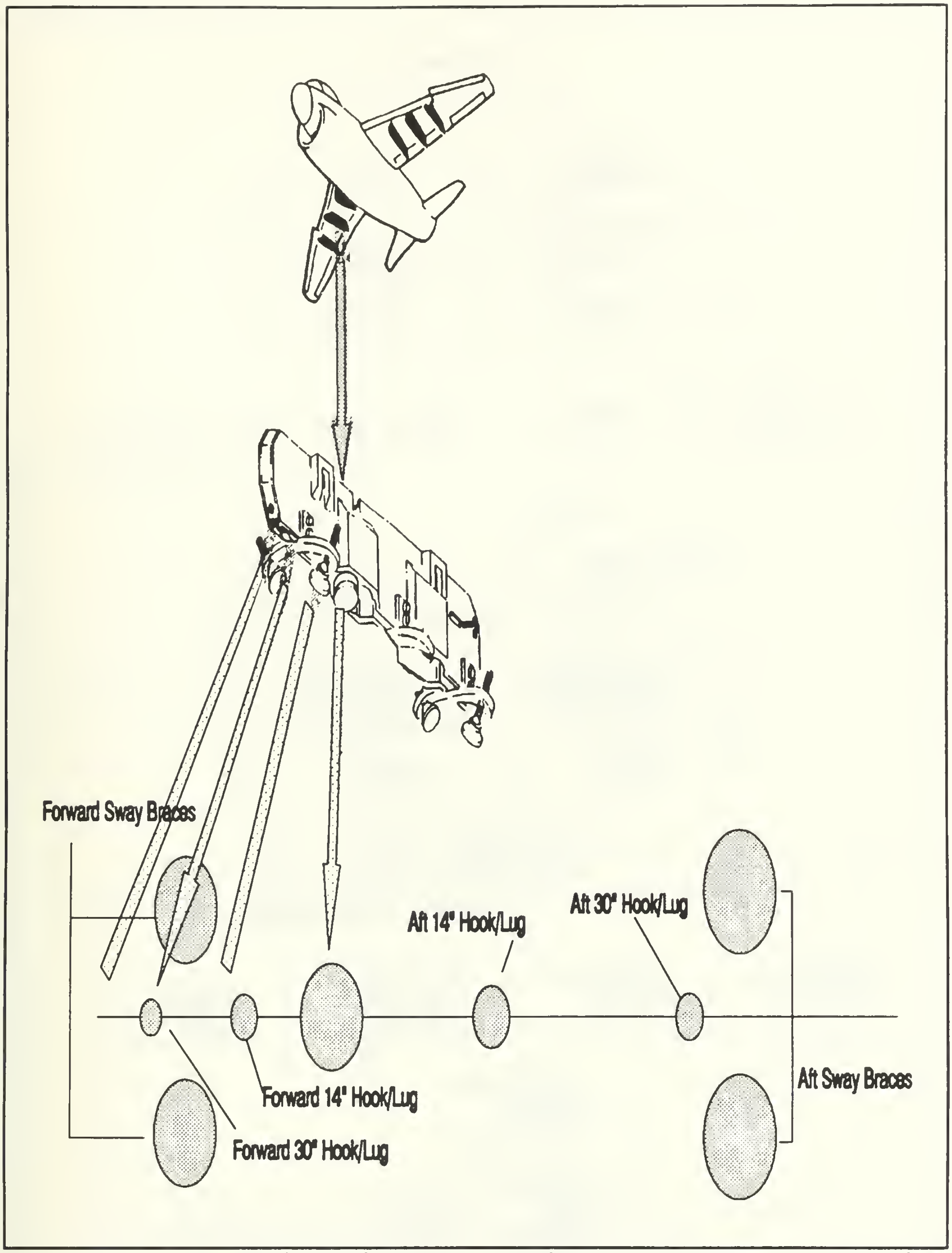


Figure 7. Relationship of Typical Bomb-Rack Top-View Drawing From Section 1 to the Actual Rack and the Carrying Aircraft.

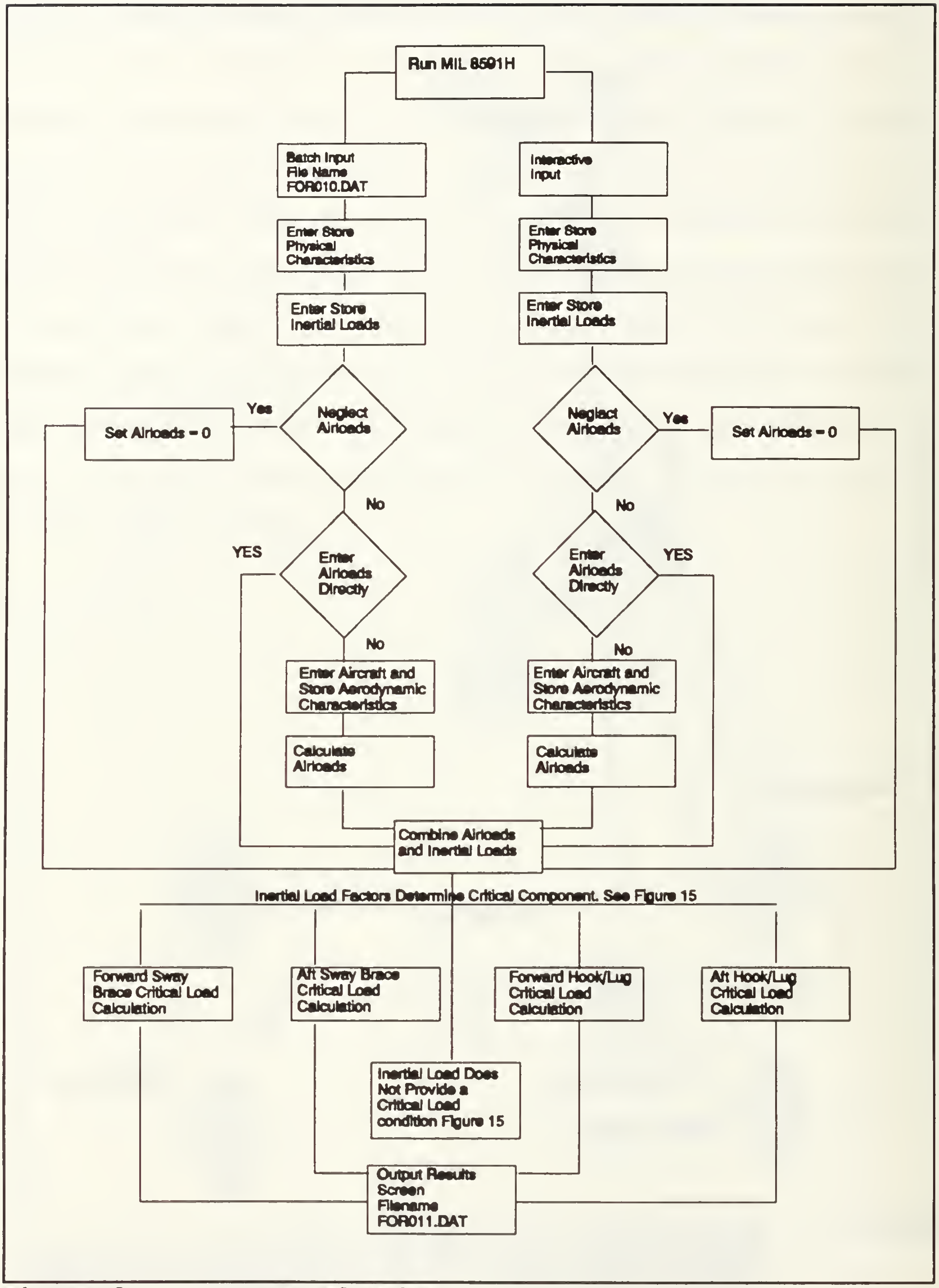


Figure 8. Program Flowchart

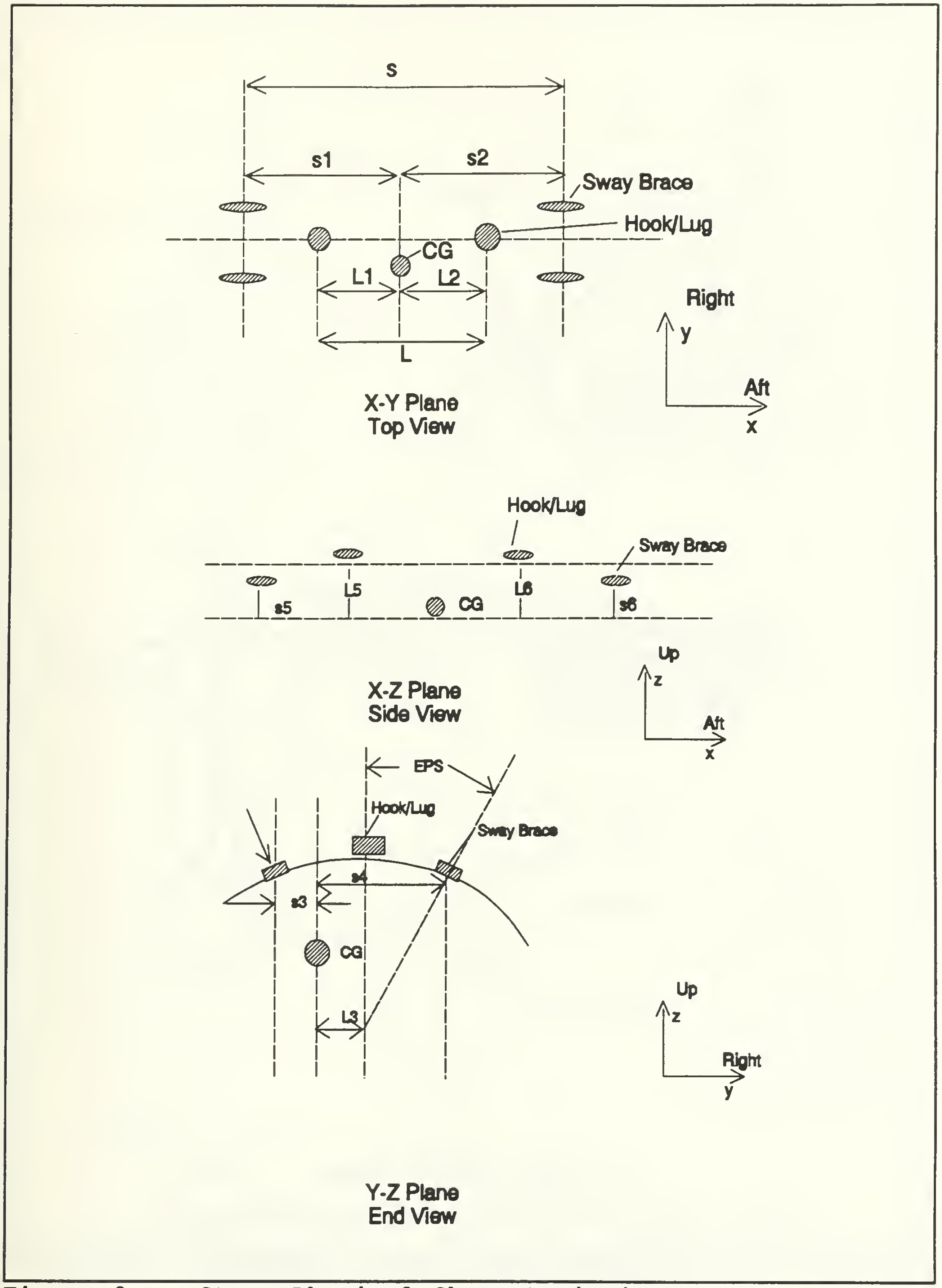
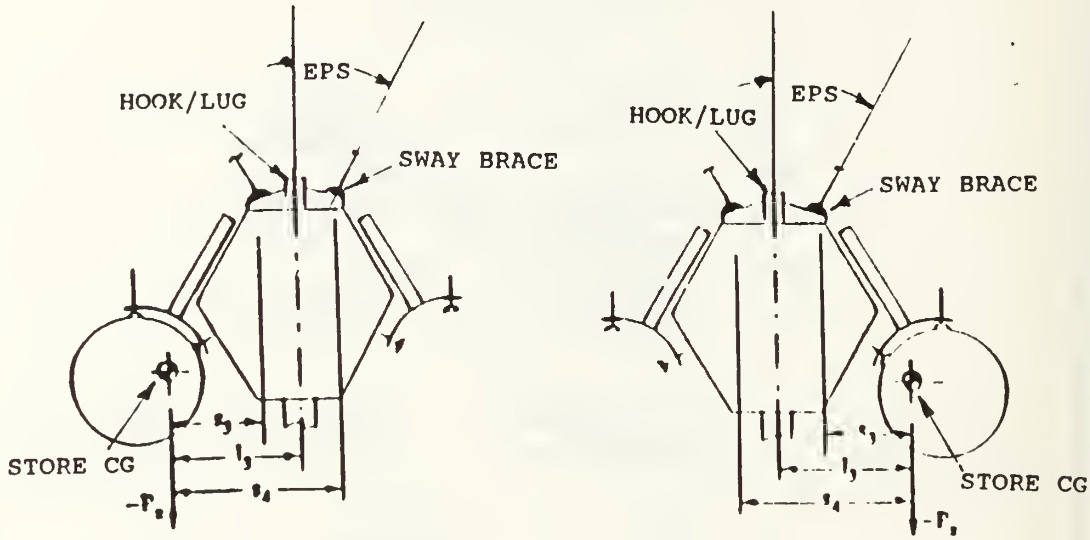
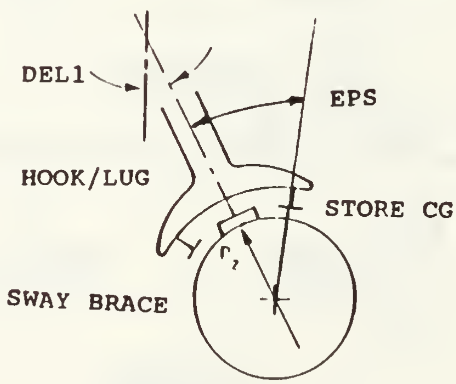


Figure 9. Store Physical Characteristics



Y-Z PLANE LOOKING FORWARD

DEL1=0 for the analysis of the hook/lug indicated



Y-Z PLANE LOOKING FORWARD

DEL1≠0 for the analysis of the hook/lug indicated

Figure 10. Store Physical Characteristics and Angles

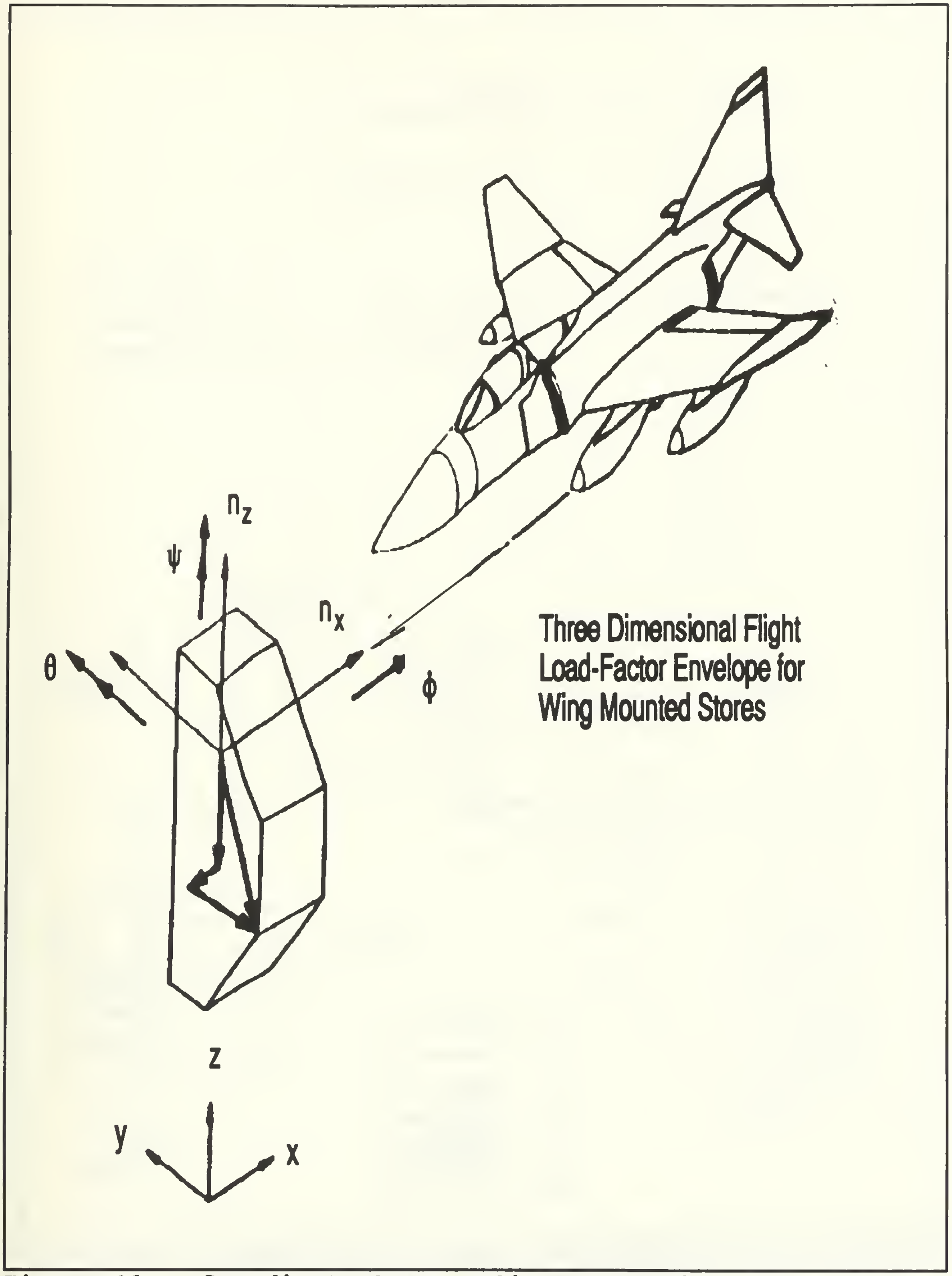


Figure 11. Coordinate System, Sign Convention, and a Typical Load Factor Envelope

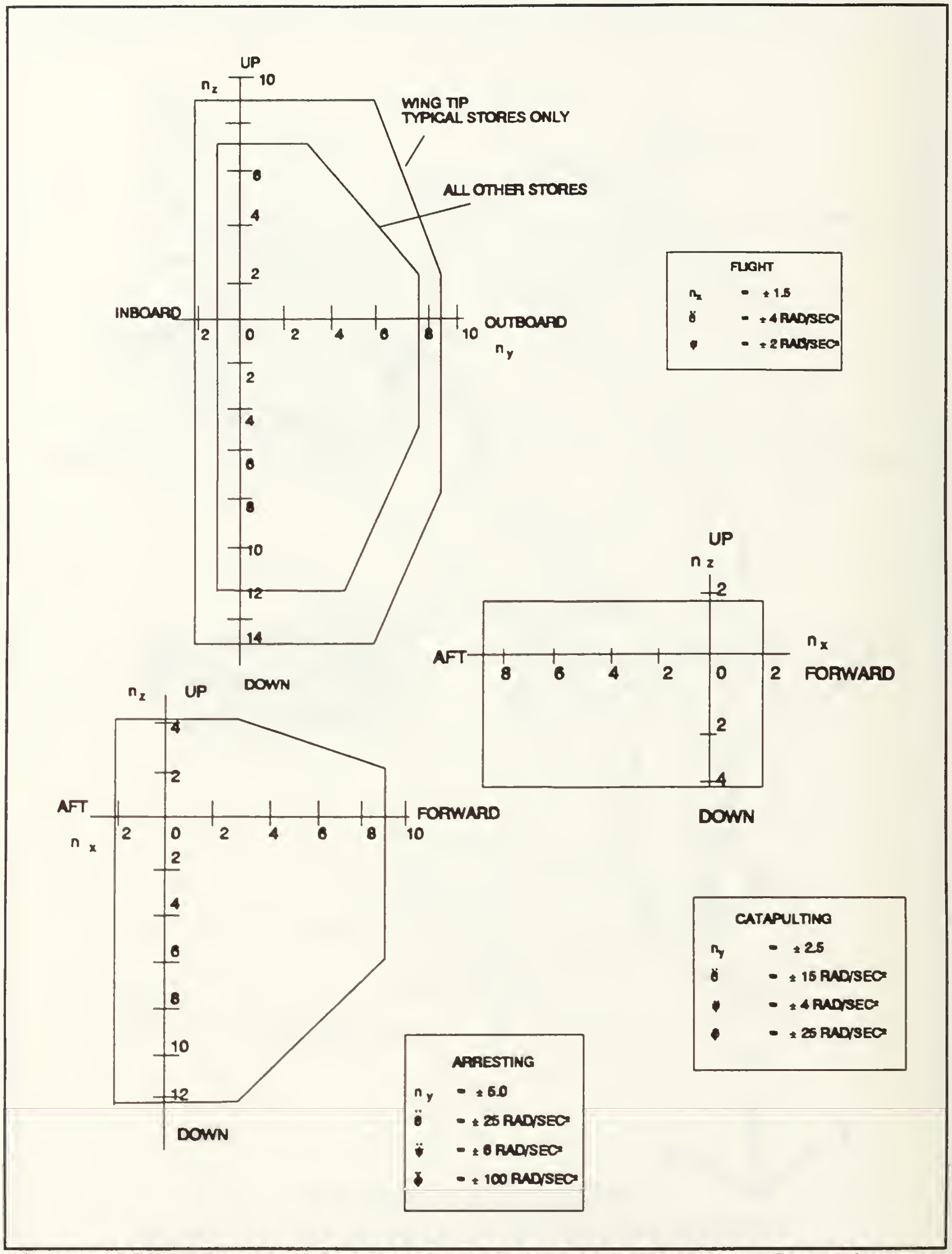


Figure 12. Design Inertial Limit Load Factors for Wing or Sponson-Mounted Stores (Data Applies at the Center of Gravity)

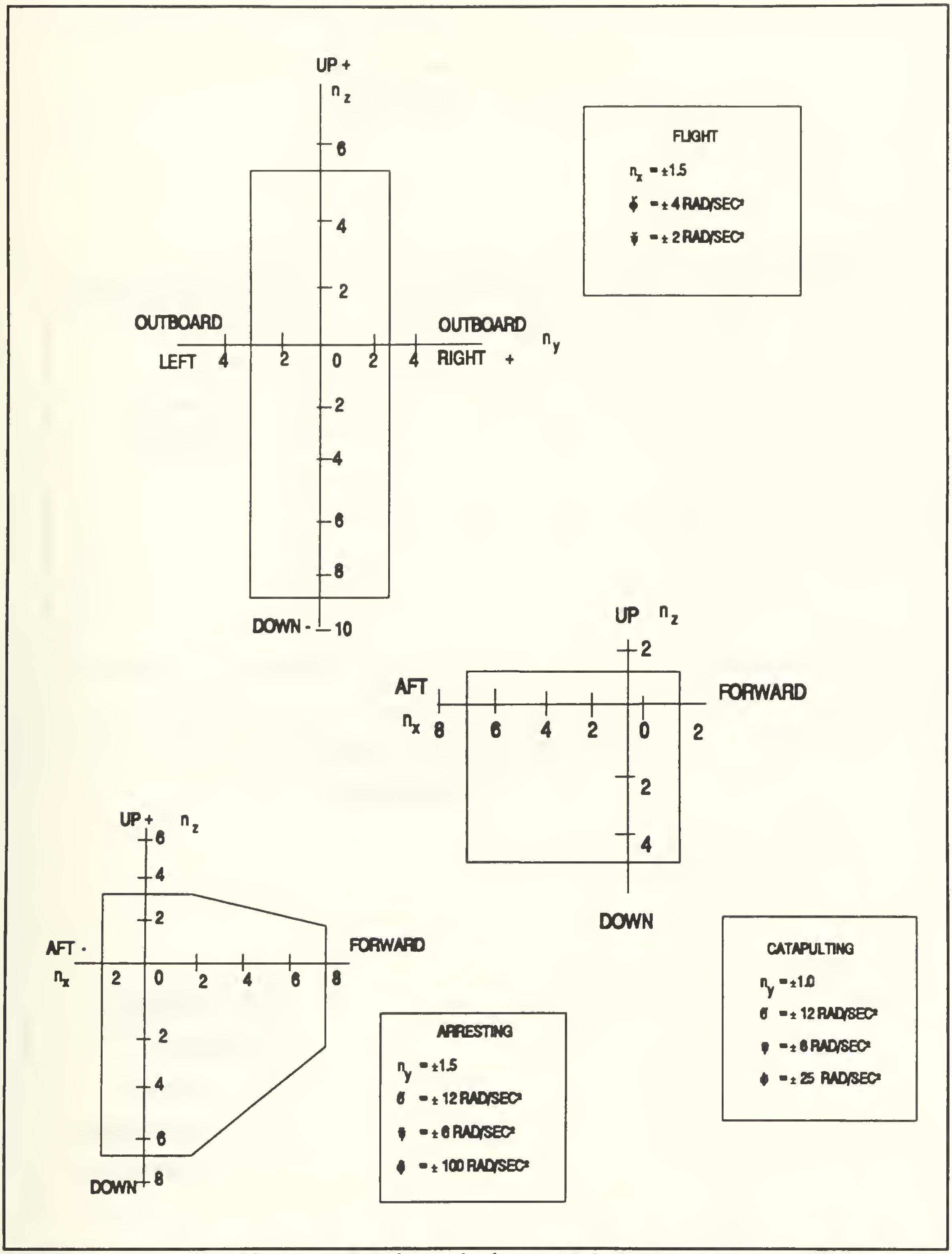


Figure 13. Design Inertia Limit Load Factors for Fuselage-Mounted Stores (Data Applies at the Store Center of Gravity)

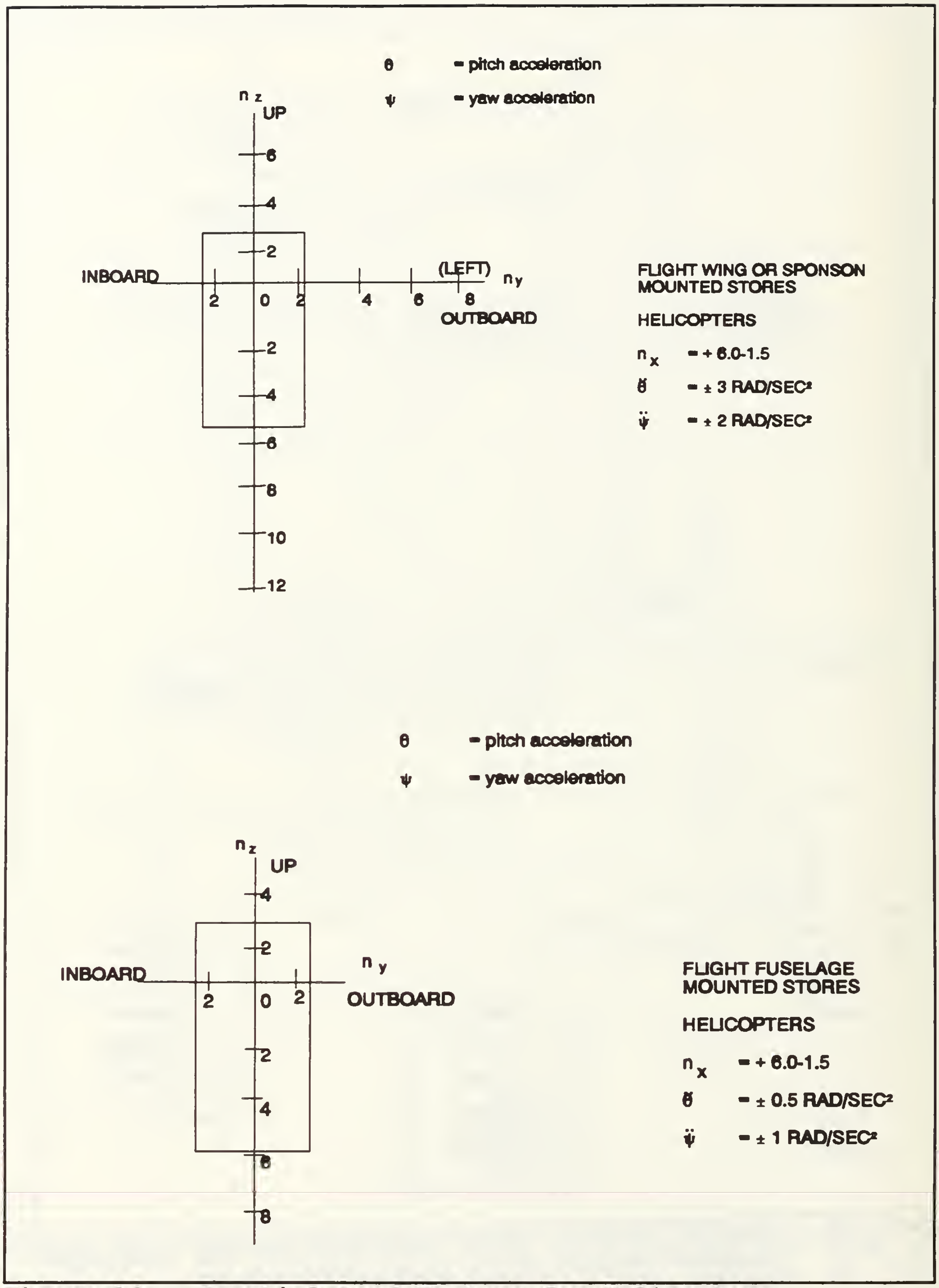


Figure 14. Inertial Load Factors for Helicopters

Store Inertial Loads	SB/store SB pad				Hook/Lug	
	Fwd		Aft			
	L	R	L	A	F	A
N_x	−	−	+	+	+	−
N_y	−	+	−	+	±	±
N_z	+(1)	+(1)	+(1)	+(1)	−	−
$\ddot{\phi}$	−	+	−	+	±	±
$\ddot{\theta}$	+	+	−	−	−	±
$\ddot{\psi}$	+	−	−	+	±	±

NOTE: (1) If the CG of the store is located laterally outside of the SB's, a negative vertical load (P_z, down) may be critical and should be investigated.

Figure 15. Direction of External Loads and Moments for Maximum Reaction Forces at the SB's/Stores SB Pads and Hooks/Lugs

For all points, the stores shall be considered to be mounted at incidence angles of 0 or -3 degress, whichever is more critical in each case, to be added to the values of α_s given below:

Points (1) and (2) (symmetric pullup):

$$\alpha_s = 0 \text{ to } + \frac{38000}{q} \text{ degrees}$$

$$\beta_s = \pm \frac{3000}{q} \text{ degrees}$$

Points (3) and (4) (pushover):

$$\alpha_s = 0 \text{ to } - \frac{22800}{q} \text{ degrees}$$

$$\beta_s = \pm \frac{3000}{q} \text{ degrees}$$

Point (5) (rolling pushover)

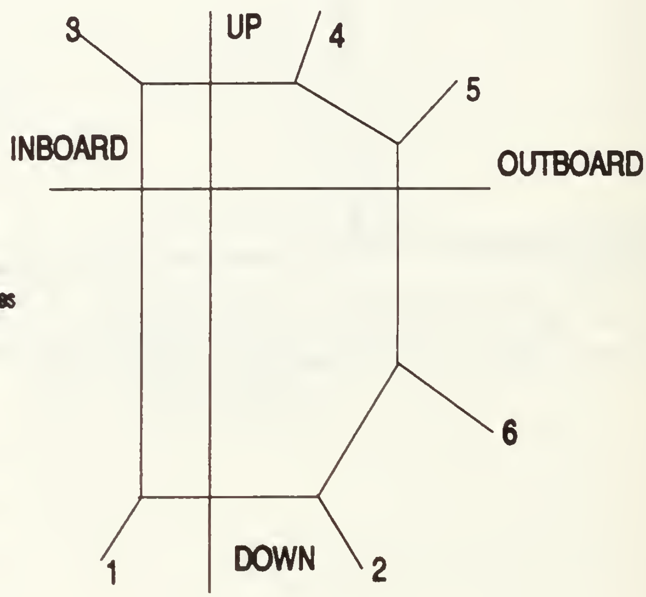
$$\alpha_s = + \frac{100}{q^{1/2}} \text{ to } - \frac{15200 + (100)(q^{1/2})}{q} \text{ degrees}$$

$$\beta_s = \pm \frac{13000}{q} \text{ degrees}$$

Point (6) (rolling pullout):

$$\alpha_s = 0 \text{ to } - \frac{30400 + (100)(q^{1/2})}{q} \text{ degrees}$$

$$\beta_s = \pm \frac{13000}{q} \text{ degrees}$$



where

α_s = store angle of attack

β_s = store angle of sideslip

$q = \frac{\rho V^2}{2}$, dynamic pressure

Figure 16. Store Angles of Attack and Sideslip at Specific Load Envelope Points for Wing or Sponson-Mounted Stores.

For all points, the stores shall be considered to be mounted at incidence angles of 0 or -3 degress, whichever is more critical in each case, to be added to the values of α_S given below:

Points (1) and (2) (pullup):

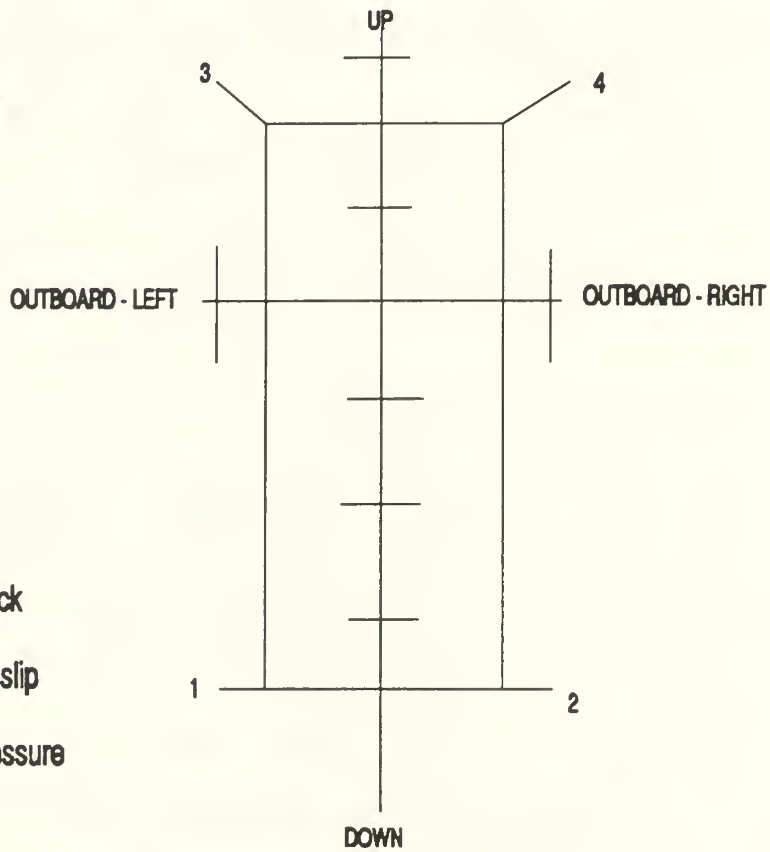
$\alpha_s = 0 \text{ to } +\frac{38000}{q}$ degrees

$\beta_s = \pm\frac{13000}{q}$ degrees

Points (3) and (4) (pushover):

$\alpha_s = 0 \text{ to } -\frac{30400}{q}$ degrees

$\beta_s = \pm\frac{13000}{q}$ degrees



where

α_S = store angle of attack

β_S = store angle of sideslip

$q = \frac{\rho V^2}{2}$, dynamic pressure

Figure 17. Store Angles of Attack and Sideslip at Specific Load Envelope Points for Fuselage-Mounted Stores.

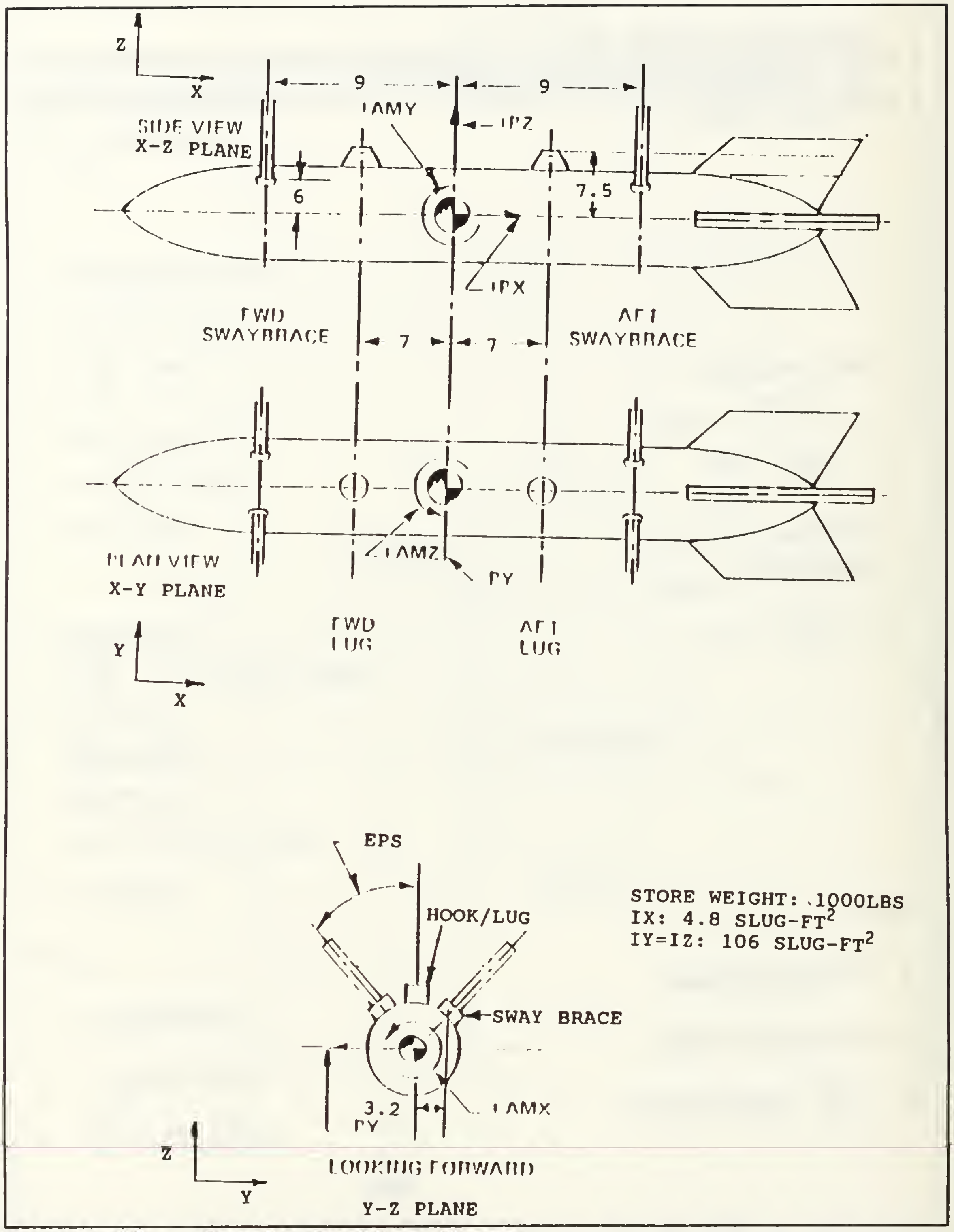


Figure 18. Sample Problem Store

XII. GLOSSARY

AMXA	Aerodynamic roll moment (in-lbs)
AMYA	Aerodynamic pitch moment (in-lbs)
AMZA	Aerodynamic yaw moment (in-lbs)
ANGA	Store angle of attack of store (deg), α_s
ANGS	Store angle of side-slip (deg), β_s
DEL1	Rotation around the X-axis for stores mounted at a roll angle W.R.T. the aircraft axis system. (deg)
DEN	Air density (slug/ft^3)
EPS	Angle between radius of curvature of store and Z-axis (eps) deg.
IX	Mass moment of inertia X-axis slug-ft**2
IY	Mass moment of inertia Y-axis slug-ft**2
IZ	Mass moment of inertia Z-axis slug-ft**2
L	Distance between lugs (in)
L1	Distance store CG to fwd lug X-direction (in)
L2	Distance store CG to aft lug X-direction (in)
L3	Distance store CG to fwd lug Y-direction (in)
L4	Distance store CG to aft lug Y-direction (in). Note L3 usually equal to L4
L5	Distance store CG to fwd lug Z-direction (in)
L6	Distance store CG to aft lug Z-direction (in). Note L5 usually equal to L6
LR	Reference length (in)

LTOTAFT	Aft lug shear force X-Y plane (lbs)
LTOTFWD	Forward lug shear force X-Y plane (lbs)
LXAFT	Aft lug reaction force X-direction (lbs)
LXFWD	Forward lug reaction force X-direction (lbs)
LYAFT	Aft lug reaction force Y-direction (lbs)
LYFWD	Forward lug reaction force Y-direction (lbs)
LZAFT	Aft lug reaction force Z-direction (lbs)
LZFWD	Forward lug reaction force Z-direction (lbs)
MX	External moments X-direction PHIDD*IX (in-lbs)
MXC	Combined aero and inertial moment roll-axis store coordinate system (in-lbs)
MY	External moments Y-direction THEDD*IY (in-lbs)
MYC	Combined aero and inertial moment pitch-axis store coordinate system (in-lbs)
MZ	External moments Z-direction PSIDD*IZ (in-lbs)
MZC	Combined aero and inertial moment yaw-axis store coordinate system (in-lbs)
NX	Acceleration X-direction (g)
NY	Acceleration Y-direction (g)
NZ	Acceleration Z-direction (g)
PHIDD	$\ddot{\phi}$ Angular acceleration X-axis (rad/sec**2)
PSIDD	$\ddot{\psi}$ Angular acceleration Z-axus (rad/sec**2)
PX	External loads X-direction W*NX (lbs)
PXA	External airloads X-direction (lbs)

PXC	Combined airloads and inertial loads X-direction store coordinate system PX+PXA (lbs)
PY	External loads Y-direction W*NY
PYA	External airloads Y-direction (lbs)
PYC	Combined airloads and inertial loads Y-direction store coordinate system PY+PYA (lbs)
PZ	External loads Z-direction W*NZ (lbs)
PZA	External airloads Z-direction
PZC	Combined airloads and inertial loads Z-direction store coordinate system PZ+PZA (lbs)
QUE	Dynamic pressure (lb/ft-sq)
R	Reference radius (in)
S	Distance between forward and aft sway brace pads (in)
S1	Distance store CG to fwd sway brace pad X-direction (in)
S2	Distance store CG to aft sway brace pad X-direction (in)
S3	Distance store CG to near sway brace pad Y-direction (in)
S4	Distance store CG to far sway brace pad Y-direction (in). Note S3 equal to S4 when store symmetric
S5	Distance store CG to right sway brace pad Z-direction (in)
S6	Distance store CG to left sway brace pad Z-direction. Note S5 usually equal to S6

SR	Reference area (ft-sq)
STOTAFT	Total aft sway brace load (lbs)
STOTFWD	Total forward sway brace load (lbs)
SYAFT	Aft sway brace reaction force Y-direction (lbs)
SYFWD	Forward sway brace reaction force Y-direction (lbs)
SZAFT	Aft sway brace reaction force Z-direction (lbs)
SZFWD	Forward sway brace reaction force Z-direction (lbs)
THEDD	$\ddot{\theta}$ Angular acceleration Y-axis (rad/sec**2)
VEL	Aircraft velocity (ft/sec)
W	Weight of store (lbs)

APPENDIX B: PROGRAM MIL8591H COMPUTER CODE*

```
      PROGRAM MIL8591
C* PROGRAM TO COMPUTE STORE LOADS USING MIL-A-8591H
C*
C*  DEFINITON OF TERMS
C*  W-WEIGHT OF STORE LBS
C*  IX-MASS MOMENT OF INERTIA X-AXIS SLUG-FT**2
C*  IY-MASS MOMENT OF INERTIA Y-AXIS SLUG-FT**2
C*  IZ-MASS MOMENT OF INERTIA Z-AXIS SLUG-FT**2
C*  ALL DISTANCES IN INCHES
C*  S- DISTANCE BETWEEN FORWARD AND AFT SWAY BRACE PADS
C*  S1-DISTANCE STORE CG TO FWD SWAY BRACE PAD X-DIRECTION
C*  S2-DISTANCE STORE CG TO AFT SWAY BRACE PAD X-DIRECTION
C*  S3-DISTANCE STORE CG TO NEAR SWAY BRACE PAD Y-DIRECTION
C*  S4-DISTANCE STORE CG TO FAR SWAY BRACE PAD Y-DIRECTION
C*  NOTE S3 EQUAL TO S4 WHEN STORE SYMMETRIC
C*  S5-DISTANCE STORE CG TO RIGHT SWAY BRACE PAD Z-DIRECTION
C*  S6-DISTANCE STORE CG TO LEFT SWAY BRACE PAD Z-DIRECTION
C*  NOTE S5 USUALLY EQUAL TO S6
C*  L- DISTANCE BETWEEN LUGS
C*  L1-DISTANCE STORE CG TO FWD LUG X-DIRECTION
C*  L2-DISTANCE STORE CG TO AFT LUG X-DIRECTION
C*  L3-DISTANCE STORE CG TO FWD LUG Y-DIRECTION
C*  L4-DISTANCE STORE CG TO AFT LUG Y-DIRECTION
C*  NOTE L3 USUALLY EQUAL TO L4
C*  L5-DISTANCE STORE CG TO FWD LUG Z-DIRECTION
C*  L6-DISTANCE STORE CG TO AFT LUG Z-DIRECTION
C*  NOTE L5 USUALLY EQUAL TO L6
C*  LXFWD-FORWARD LUG REACTION FORCE X-DIRECTION LBS
C*  LYFWD-FORWARD LUG REACTION FORCE Y-DIRECTION LBS
C*  LZFWD-FORWARD LUG REACTION FORCE Z-DIRECTION LBS
C*  LXAFT-AFT LUG REACTION FORCE X-DIRECTION LBS
C*  LYAFT-AFT LUG REACTION FORCE Y-DIRECTION LBS
C*  LZAFT-AFT LUG REACTION FORCE Z-DIRECTION LBS
C*  LTOTFWD- FORWARD LUG SHEAR FORCE X-Y PLANE LBS
C*  LTOTAFT- AFT LUG SHEAR FORCE X-Y PLANE LBS
C*  SYFWD- FORWARD SWAY BRACE REACTION FORCE Y-DIRECTION LBS
C*  SZFWD-FORWARD SWAY BRACE REACTION FORCE Z-DIRECTION LBS
C*  STOTFWD- TOTAL FORWARD SWAY BRACE LOAD LBS
C*  SYAFT-AFT SWAY BRACE REACTION FORCE Y-DIRECTION LBS
C*  SZAFT-AFT SWAY BRACE REACTION FORCE Z-DIRECTION LBS
C*  STOTAFT- TOTAL AFT SWAY BRACE LOAD LBS
C*  NX-ACCELLERATION X-DIRECTION
C*  NY-ACCELLERATION Y-DIRECTION
C*  NZ-ACCELLERATION Z-DIRECTION
C*  PX-EXTERNAL LOADS X-DIRECTION W*NX
C*  PY-EXTERNAL LOADS Y-DIRECTION W*NY
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* copy of the computer program may be obtained by writing to the chairman of the Department of Aeronautics and Astronautics

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C*   PZ-EXTERNAL LOADS Z-DIRECTION W*NZ
C*   PHIDD-ANGULAR ACCELERATION X-DIRECTION RAD/SEC**2
C*   THEDD-ANGULAR ACCELERATION Y-DIRECTION RAD/SEC**2
C*   PSIDD-ANGULAR ACCELERATION Z-DIRECTION RAD/SEC**2
C*   MX-EXTERNAL MOMENTS X-DIRECTION PHIDD*I
C*   MY-EXTERNAL MOMENTS Y-DIRECTION THEDD*I
C*   MZ-EXTERNAL MOMENTS Z-DIRECTION PSIDD*I
C*   PXA-EXTERNAL AIRLOADS X-DIRECTION
C*   PYA-EXTERNAL AIRLOADS Y-DIRECTION
C*   PZA-EXTERNAL AIRLOADS Z-DIRECTION
C*   AMXA-AERODYNAMIC ROLL MOMENT
C*   AMYA-AERODYNAMIC PITCH MOMENT
C*   AMZA-AERODYNAMIC YAW MOMENT
C*   PXC-COMBINED AIRLOADS AND INERTIAL LOADS X-DIRECTION STORE COORD SYS
C*   PYC-COMBINED AIRLOADS AND INERTIAL LOADS Y-DIRECTION STORE COORD SYS
C*   PZC-COMBINED AIRLOADS AND INERTIAL LOADS Z-DIRECTION STORE COORD SYS
C*   MXC-COMBINED AERO AND INERTIAL MOMENT ROLL-DIRECTION STORE COORD SYS

C*   MYC-COMBINED AERO AND INERTIAL MOMENT PITCH-DIRECTION STORE COORD SYS
C*   MZC-COMBINED AERO AND INERTIAL MOMENT YAW-DIRECTION STORE COORD SYS
C*
C*   ANGA - ANGLE OF ATTACK OF STORE (DEG)
C*   ANGS - ANGLE OF SIDE-SLIP (DEG)
C*   QUE - DYNAMIC PRESSURE (LB/FT-SQ)
C*   VEL - AIRCRAFT VELOCITY (FT/SEC)
C*   DEN - AIR DENSITY (SLUG/FT^3)
C*   SR - REFERENCE AREA (FT-SQ)
C*   R - REFERENCE RADIUS (IN)
C*   LR - REFERENCE LENGTH (IN)
C*   C1 - LIFT COEFFICIENT SLOPE (PER DEG)
C*   C2 - PITCH MOMENT COEFFICIENT SLOPE (PER DEG)
C*   C6 - SIDE FORCE COEFFICIENT SLOPE (PER DEG)
C*   C7 - YAW MOMENT COEFFICIENT SLOPE (PER DEG)
C*   CD - DRAG COEFFICIENT
C*   EPS- ANGLE BETWEEN RADIUS OF CURVATURE OF STORE AND Z-AXIS (EPS) DEG.
C*   DEL1-ROTATION AROUND THE X-AXIS FOR STORES MOUNTED AT
C*        A ROLL ANGLE W.R.T. THE AIRCRAFT AXIS SYSTEM DEG

C*   THESE ARE VARIABLES USED IN THE SUBROUTINES TO CALCULATE LOADS
         INCLUDE 'TOPJUNK.INC'
      WRITE (6,*)'ENTER 1 FOR INTERACTIVE 2 FOR BATCH IO'
      READ (5,*) NN
      OPEN (UNIT=11,FILE='FOR011.DAT',STATUS='UNKNOWN')
         IF (NN.EQ.1) THEN
            NUMIN=5
            NUMOUT=6
         CALL GETDATA1
         ELSE
            NUMIN=10
         NUMOUT=11
         CALL GETDATA2
         ENDIF
      CALL AIRLOAD
      CALL ADDLOAD
      CALL ROTATE
      IF (NN.EQ.1)THEN
      NUMOUT=11
      ENDIF
C*   IF THE CG IS LATERALLY BETWEEN THE SWAY BRACES THEN PZ
C*   POSITIVE OR UP IS THE WORST CASE
```

```
C*   IF THE CG OF THE STORE IS LATERALLY OUTSIDE THE SWAY BRACES
C*   A NEGATIVE OR DOWN PZ MUST ALSO BE ANALYSED

      IF(CHSB.EQ.1 .OR. CHSB.EQ.3 .OR. CHSB.EQ.6)THEN

           IF(NX.LT.0.AND.NY.LT.0.AND.NZ.GT.0.AND.THEDD
     >   .GT.0.AND.PSIDD.GT.O)THEN
      WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE FWD LEFT SWAY BRACE'
         PRINT *,'WORST CASE LOAD IS AT THE FWD LEFT SWAY BRACE'
      CALL FSWYBRC

         ELSEIF(NX.LT.0.AND.NY.GT.0.AND.NZ.GT.0.AND.
     >   THEDD.GT.0.AND.PSIDD.LT.O)THEN
         WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE FWD RIGHT SWAY BRACE'
         PRINT *,'WORST CASE LOAD IS AT THE FWD RIGHT SWAY BRACE'
         CALL FSWYBRC

         ELSEIF(NX.GT.0.AND.NY.LT.0.AND.NZ.GT.0.AND.THEDD
     >   .LT.0.AND.PSIDD.LT.O)THEN

         WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE AFT LEFT SWAY BRACE'
         PRINT *,'WORST CASE LOAD IS AT THE AFT LEFT SWAY BRACE'
         CALL ASWYBRC

         ELSEIF(NX.GT.0.AND.NY.GT.0.AND.NZ.GT.0.AND.THEDD
     >   .LT.0.AND.PSIDD.GT.O)THEN

         WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE AFT RIGHT SWAY BRACE'

         PRINT *,'WORST CASE LOAD IS AT THE AFT RIGHT SWAY BRACE'
         CALL ASWYBRC

      ELSEIF(NX.GT.0.AND.NZ.LT.0.AND.THEDD.LT.0)THEN
         WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE FORWARD HOOK'
         PRINT *,'WORST CASE LOAD IS AT THE FORWARD HOOK'
      CALL FHOOK

         ELSEIF(NX.LT.0.AND.NZ.LT.0)THEN
         WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE AFT HOOK'
         PRINT *,'WORST CASE LOAD IS AT THE AFT HOOK'
         CALL AHOOK

      ELSE
          WRITE(NUMOUT,*)'THE INERTIAL "G" FACTORS AND ANGULAR'
      WRITE(NUMOUT,*)'ACCELERATIONS YOU ENTERED DO NOT PROVIDE'
         WRITE(NUMOUT,*)'A WORST CASE LOAD. CONSULT TABLE D-1;'
         WRITE(NUMOUT,*)'APPENDIX D MIL-8591H.'
      PRINT *,'THE INERTIAL "G" FACTORS AND ANGULAR'
         PRINT *,'ACCELERATIONS YOU ENTERED DO NOT PROVIDE'
         PRINT *,'A WORST CASE LOAD. CONSULT TABLE D-1;'
         PRINT *,'APPENDIX D MIL-8591H.'
      ENDIF

C*   IF THE CG OF THE STORE IS LATERALLY OUTSIDE THE SWAY BRACES
C*   A NEGATIVE OR DOWN PZ MUST BE ANALYSED

      ELSEIF(CHSB.EQ.2.OR. CHSB.EQ.4.OR. CHSB.EQ.5.OR.CHSB.EQ.7)THEN

         IF(NX.LT.0.AND.NY.LT.0.AND.NZ.GT.0.AND.PHIDD.LT.0.AND.THEDD
     >   .GT.0.AND.PSIDD.GT.O)THEN
         WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE FWD LEFT SWAY BRACE'
```

```
    PRINT *,'WORST CASE LOAD IS AT THE FWD LEFT SWAY BRACE'
    CALL FSWYBRC

    ELSEIF(NX.LT.0.AND.NY.GT.0.AND.PHIDD.GT.0.AND.
>   THEDD.GT.0.AND.PSIDD.LT.O)THEN
    WRITE(NUMOUT,*)'**********************************************'
    WRITE(NUMOUT,*)'STORE CG IS LATERALLY OUTSIDE SWAY BRACES'
    WRITE(NUMOUT,*)'THEREFORE AFT HOOK AND FWD SWAY BRACE'
    WRITE(NUMOUT,*)'SHOULD BE ANALYSED'
    WRITE(NUMOUT,*)'**********************************************'
    PRINT *,'*****************************************************'
    PRINT *,'STORE CG IS LATERALLY OUTSIDE SWAY BRACES'
    PRINT *,'THEREFORE AFT HOOK AND FWD SWAY BRACE'
    PRINT *,'SHOULD BE ANALYSED'
    PRINT *,'*****************************************************'
PRINT *,' '
    WRITE(NUMOUT,*)
    WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE AFT HOOK'
    PRINT *,'WORST CASE LOAD IS AT THE AFT HOOK'
    WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE FWD RIGHT SWAY BRACE'
    PRINT *,'WORST CASE LOAD IS AT THE FWD RIGHT SWAY BRACE'
    WRITE(NUMOUT,*)
    CALL FSWYBRC
CALL AHOOK

    ELSEIF(NX.GT.0.AND.NY.LT.0.AND.PHIDD.LT.0.AND.THEDD
>   .LT.0.AND.PSIDD.LT.O)THEN
    WRITE(NUMOUT,*)'**********************************************'
    WRITE(NUMOUT,*)'STORE CG IS LATERALLY OUTSIDE SWAY BRACES'
    WRITE(NUMOUT,*)'THEREFORE FWD HOOK AND AFT SWAY BRACE'
    WRITE(NUMOUT,*)'SHOULD BE ANALYSED'
    WRITE(NUMOUT,*)'**********************************************'
    PRINT *,'*****************************************************'
    PRINT *,'STORE CG IS LATERALLY OUTSIDE SWAY BRACES'
    PRINT *,'THEREFORE FWD HOOK AND AFT SWAY BRACE'
    PRINT *,'SHOULD BE ANALYSED'
    PRINT *,'*****************************************************'
    WRITE(NUMOUT,*)
PRINT *,' '
    WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE AFT LEFT SWAY BRACE'
    PRINT *,'WORST CASE LOAD IS AT THE AFT LEFT SWAY BRACE'
    WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE FORWARD HOOK'
    PRINT *,'WORST CASE LOAD IS AT THE FORWARD HOOK'
    CALL ASWYBRC
CALL FHOOK

    ELSEIF(NX.GT.0.AND.NY.GT.0.AND.NZ.GT.0.AND.PHIDD.GT.0.AND.THEDD
>   .LT.0.AND.PSIDD.GT.O)THEN
    WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE AFT RIGHT SWAY BRACE'
    PRINT *,'WORST CASE LOAD IS AT THE AFT RIGHT SWAY BRACE'
    CALL ASWYBRC

    ELSEIF(NX.GT.0.AND.NZ.LT.0.AND.THEDD.LT.0)THEN
    WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE FORWARD HOOK'
    PRINT *,'WORST CASE LOAD IS AT THE FORWARD HOOK'
    CALL FHOOK

    ELSEIF(NX.LT.0.AND.NZ.LT.0)THEN
    WRITE(NUMOUT,*)'WORST CASE LOAD IS AT THE AFT HOOK'
    PRINT *,'WORST CASE LOAD IS AT THE AFT HOOK'
    CALL AHOOK
```

```
      ELSE
      WRITE(NUMOUT,*)'THE INERTIAL "G" FACTORS AND ANGULAR'
      WRITE(NUMOUT,*)'ACCELERATIONS YOU ENTERED DO NOT PROVIDE'
      WRITE(NUMOUT,*)'A WORST CASE LOAD. CONSULT TABLE D-1;'
      WRITE(NUMOUT,*)'APPENDIX D MIL-8591H.'
      PRINT *,'THE INERTIAL "G" FACTORS AND ANGULAR'
      PRINT *,'ACCELERATIONS YOU ENTERED DO NOT PROVIDE'
      PRINT *,'A WORST CASE LOAD. CONSULT TABLE D-1;'
      PRINT *,'APPENDIX D MIL-8591H.'
      ENDIF
   ENDIF

   CALL OUTPUT
      IF (NN.EQ.1)THEN
      NUMOUT=6
      CALL OUTPUT
      ENDIF
      IF (NN.EQ.2)THEN
      NUMOUT=6
      CALL OUTPUT
      ENDIF
      STOP
      END

      SUBROUTINE OUTPUT
      INCLUDE 'TOPJUNK.INC'
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'              **INERTIAL LOADS APPLIED**'
      WRITE(NUMOUT,*)'   LOAD FACTOR G"S        ANGULAR ACCELERATION
   >  RAD/SEC**2'
      WRITE(NUMOUT,*)'LONGITUDINAL=',NX,' ROLL=',PHIDD
      WRITE(NUMOUT,*)'LATERAL     =',NY,'PITCH=',THEDD
      WRITE(NUMOUT,*)'VERTICAL    =',NZ,'  YAW=',PSIDD
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'              **AERODYNAMIC LOADS APPLIED**'
      WRITE(NUMOUT,*)'    AIRLOAD LB            AERODYNAMIC MOMENT
   >  IN-LB'
      WRITE(NUMOUT,*)'LONGITUDINAL =',PXA,'  ROLL =',AMXA
      WRITE(NUMOUT,*)'LATERAL      =',PYA,' PITCH =',AMYA
      WRITE(NUMOUT,*)'VERTICAL     =',PZA,'   YAW =',AMZA
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'STORE WEIGHT LBS =',W
      WRITE(NUMOUT,*)'MASS MOMENT OF INERTIA X-AXIS LB-IN-SEC^2 =',IX
      WRITE(NUMOUT,*)'MASS MOMENT OF INERTIA Y-AXIS LB-IN-SEC^2 =',IY
      WRITE(NUMOUT,*)'MASS MOMENT OF INERTIA Z-AXIS LB-IN-SEC^2 =',IZ
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'HOOK/LUG SPACING IN. =',L
      WRITE(NUMOUT,*)'THE STORE CG IS',L1,'IN FROM THE FWD HOOK/LUG'
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'LONGITUDINAL SWAY BRACE SPACING IN =',S
      WRITE(NUMOUT,*)'THE STORE CG IS',S1,'IN FROM THE FWD SWAY BRACE'
   IF (CHAL.EQ.3)THEN
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'AIRLOADS WERE CALCULATED CASE 3'
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'AIRCRAFT VELOCITY FT/SEC    =',VEL
      WRITE(NUMOUT,*)'STORE ANGLE OF ATTACK DEG   =',ANGA
      WRITE(NUMOUT,*)'STORE ANGLE OF SIDESLIP DEG =',ANGS
```

```
     ENDIF

        RETURN
        END

        SUBROUTINE GETDATA1
        INCLUDE 'TOPJUNK.INC'
     WRITE (NUMOUT,*)'INPUT STORE CG POSITION WITH RESPECT TO
     > SWAY BRACE PADS. ENTER THE NUMBER
     >    CORRESPONDING TO THE CONDITION'
        WRITE   (NUMOUT,*)'1-   STORE   CG   BETWEEN   SWAY   BRACE   PADS
LONGITUDINALLY
     > AND LATERALLY'
        WRITE (NUMOUT,*)
        WRITE   (NUMOUT,*)'2-   STORE   CG   BETWEEN   SWAY   BRACE   PADS
LONGITUDINALLY
     > BUT OUTSIDE SWAY BRACE PADS          LATERALLY'
        WRITE (NUMOUT,*)
        WRITE (NUMOUT,*)'3- STORE CG FORWARD OF FRONT SWAY BRACE PAD
     > LONGITUDINALLY, BUT BETWEEN SWAY BRACE   PADS LATERALLY'
        WRITE (NUMOUT,*)
        WRITE (NUMOUT,*)'4- STORE CG FORWARD OF FRONT SWAY BRACE PAD
     > LONGITUDINALLY, AND OUITSIDE             SWAY BRACE PADS LATERALLY'
        WRITE (NUMOUT,*)
        WRITE (NUMOUT,*)'5- STORE CG BETWEEN SWAY BRACE PAD
     > LONGITUDINALLY, BUT OUTSIDE SWAY BRACE PADS       LATERALLY'

        WRITE (NUMOUT,*)
        WRITE (NUMOUT,*)'6- STORE CG AFT OF REAR SWAY BRACE PAD
     > LONGITUDINALLY, BUT BETWEEN SWAY BRACE       PADS LATERALLY'
        WRITE (NUMOUT,*)
        WRITE (NUMOUT,*)'7- STORE CG AFT OF REAR SWAY BRACE PAD
     > LONGITUDINALLY, AND OUTSIDE SWAY BRACE        PADS LATERALLY'
     READ (NUMIN,*) CHSB
     IF (CHSB.EQ.1)THEN
        WRITE   (NUMOUT,*)'1-   STORE   CG   BETWEEN   SWAY   BRACE   PADS
LONGITUDINALLY
     >  AND LATERALLY'
        WRITE (NUMOUT,*)
        ELSEIF (CHSB.EQ.2)THEN
        WRITE   (NUMOUT,*)'2-   STORE   CG   BETWEEN   SWAY   BRACE   PADS
LONGITUDINALLY
     >  BUT OUTSIDE SWAY BRACE PADS LATERALLY'

        WRITE (NUMOUT,*)
        ELSEIF (CHSB.EQ.3)THEN
        WRITE (NUMOUT,*)'3- STORE CG FORWARD OF FRONT SWAY BRACE PAD

     >  LONGITUDINALLY, BUT BETWEEN SWAY BRACE PADS LATERALLY'

        WRITE (NUMOUT,*)
        ELSEIF (CHSB.EQ.4)THEN
        WRITE (NUMOUT,*)'4- STORE CG FORWARD OF FRONT SWAY BRACE PAD

     >  LONGITUDINALLY, AND OUITSIDE SWAY BRACE PADS LATERALLY'

        WRITE (NUMOUT,*)
        ELSEIF (CHSB.EQ.5)THEN
        WRITE (NUMOUT,*)'5- STORE CG BETWEEN SWAY BRACE PAD
     >  LONGITUDINALLY, BUT OUTSIDE SWAY BRACE PADS LATERALLY'
```

```
      WRITE (NUMOUT,*)
      ELSEIF (CHSB.EQ.6)THEN
      WRITE (NUMOUT,*)'6- STORE CG AFT OF REAR SWAY BRACE PAD

     > LONGITUDINALLY, AND BETWEEN SWAY BRACE PADS LATERALLY'

      WRITE (NUMOUT,*)
      ELSEIF (CHSB.EQ.7)THEN
      WRITE (NUMOUT,*)'7- STORE CG AFT OF REAR SWAY BRACE PAD
     > LONGITUDINALLY, AND OUTSIDE SWAY BRACE PADS LATERALLY'

      ENDIF

      WRITE (NUMOUT,*)'INPUT STORE CG POSITION WITH RESPECT TO
     >HOOK/LUGS. ENTER THE NUMBER CORRESPONDING TO THE CONDITION'
      WRITE (NUMOUT,*)'1- STORE CG BETWEEN HOOK/LUGS'
      WRITE (NUMOUT,*)'2- STORE CG IN FRONT OF FORWARD HOOK/LUGS'
      WRITE (NUMOUT,*)'3- STORE CG AFT OF THE REAR HOOK/LUGS'

      READ (NUMIN,*) CHHL
      WRITE (NUMOUT,*)
      IF (CHHL.EQ.1)THEN
      WRITE (NUMOUT,*)'1- STORE CG BETWEEN HOOK/LUGS'
      ELSEIF (CHHL.EQ.2)THEN
      WRITE (NUMOUT,*)'2- STORE CG IN FRONT OF FORWARD HOOK/LUGS'
      ELSEIF (CHHL.EQ.3)THEN
      WRITE (NUMOUT,*)'3- STORE CG AFT OF REAR HOOK/LUGS'
     ENDIF
      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*)
     WRITE (NUMOUT,*)'INPUT STORE WEIGHT (W) LBS'
     READ (NUMIN,*) W
     WRITE (NUMOUT,*)'INPUT STORE MOMENT OF INERTIA
     > X-AXIS (IX) SLUG-FT**2'
     READ (NUMIN,*) IX
C*      CONVERT TO LB-IN-SEC**2
      IX=12*IX
     WRITE (NUMOUT,*)'INPUT STORE MOMENT OF INERTIA
     > Y-AXIS (IY) SLUG-FT**2'
     READ (NUMIN,*) IY

C*      CONVERT TO LB-IN-SEC**2
      IY=12*IY
     WRITE (NUMOUT,*)'INPUT STORE MOMENT OF INERTIA
     > Z-AXIS (IZ) SLUG-FT**2'
     READ (NUMIN,*) IZ

C*       CONVERT TO LB-IN-SEC**2
      IZ=12*IZ
     WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN FOR AND
     > AFT SWAY BRACE PADS (S) IN'
     READ (NUMIN,*) S
     WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > FOR SWAY BRACE PADS X-DIRECTION (S1) IN'
     READ (NUMIN,*) S1
     WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > AFT SWAY BRACE PADS X-DIRECTION (S2) IN'
     READ (NUMIN,*) S2
     WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > NEAR SWAY BRACE PADS Y-DIRECTION (S3) IN'
     READ (NUMIN,*) S3
```

```
      WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > FAR SWAY BRACE PADS Y-DIRECTION (S4) IN'
      READ (NUMIN,*) S4
      WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > RIGHT SWAY BRACE PADS Z-DIRECTION (S5) IN'
      READ (NUMIN,*) S5
      WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > LEFT SWAY BRACE PADS Z-DIRECTION (S6) IN'
      READ (NUMIN,*) S6
         WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN FOR AND
     > AFT LUGS X-DIRECTION (L) IN'
      READ (NUMIN,*) L
         WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > FWD LUG X-DIRECTION (L1) IN'
      READ (NUMIN,*) L1
         WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > AFT LUG X-DIRECTION (L2) IN'
      READ (NUMIN,*) L2
      WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > FWD LUG Y-DIRECTION (L3) IN'
      READ (NUMIN,*) L3
         WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > AFT LUG Y-DIRECTION (L4) IN'
      READ (NUMIN,*) L4
         WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > FWD LUG Z-DIRECTION (L5) IN'
         READ (NUMIN,*) L5
         WRITE (NUMOUT,*)'INPUT DISTANCE BETWEEN CG AND
     > AFT LUG Z-DIRECTION (L6) IN'
         READ (NUMIN,*) L6
         WRITE (NUMOUT,*)'INPUT EXTERNAL LOAD FACTOR X-DIRECTION NX'
         READ (NUMIN,*) NX
      WRITE (NUMOUT,*)'INPUT EXTERNAL LOAD FACTOR Y-DIRECTION NY'
      READ (NUMIN,*) NY
         WRITE (NUMOUT,*)'INPUT EXTERNAL LOAD FACTOR Z-DIRECTION NZ'
         READ (NUMIN,*) NZ
         WRITE (NUMOUT,*)'INPUT EXTERNAL ANGULAR ACCELLERATION
     > X-DIRECTION (PHIDD) RAD/SEC^2'
         READ (NUMIN,*) PHIDD
         WRITE (NUMOUT,*)'INPUT EXTERNAL ANGULAR ACCELLERATION
     > Y-DIRECTION (THEDD) RAD/SEC^2'
         READ (NUMIN,*) THEDD
         WRITE (NUMOUT,*)'INPUT EXTERNAL ANGULAR ACCELLERATION
     > Z-DIRECTION (PSIDD) RAD/SEC^2'
         READ (NUMIN,*) PSIDD
         WRITE(NUMOUT,*) 'INPUT ANGLE BETWEEN RADIUS OF CURVATURE
     >   OF STORE AND Z-AXIS (EPS) DEG'
         READ (NUMIN,*) EPS
      WRITE (NUMOUT,*) 'INPUT THE ROLL ANGLE BETWEEN THE AIRCRAFT AND
     >  THE STORE (DEL1) DEGREES'
      READ (NUMIN,*)DEL1

C*       CONVERT DEGREES TO RADIANS
      EPS=EPS/57.2958
      DEL1=DEL1/57.2958

      H=(L5-S5)*TAN(EPS)
      K=H+(L3+S3)

         WRITE (NUMOUT,*)'INPUT HOW AIRLOADS ARE TO BE ANALYSED.
     >   ENTER THE NUMBER CORRESPONDING TO THE METHOD DESIRED.'
```

```
      WRITE (NUMOUT,*)'1-NEGLECT AIRLOADS (IE. CATS TRAPS)'
      WRITE (NUMOUT,*)'2-INPUT AIRLOADS DIRECTLY FROM
     > WIND TUNNEL DATA'
      WRITE (NUMOUT,*)'3-CALCULATE AIRLOADS'
C*
     READ (NUMIN,*) CHAL

      IF (CHAL.EQ.1)THEN
      WRITE (NUMOUT,*)'1-NEGLECT AIRLOADS (IE. CATS TRAPS)'
      ELSEIF (CHAL.EQ.2)THEN
      WRITE (NUMOUT,*)'2-INPUT AIRLOADS DIRECTLY FROM
     > WIND TUNNEL DATA'
      ELSEIF (CHAL.EQ.3)THEN
      WRITE (NUMOUT,*)'3-CALCULATE AIRLOADS'
     ENDIF
      RETURN
      END

      SUBROUTINE GETDATA2
      INCLUDE 'TOPJUNK.INC'
     READ(NUMIN,'(A)') COM
     READ (NUMIN,*) CHSB
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) CHHL
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) W
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) IX
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) IY

      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) IZ

      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) S
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) S1
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) S2
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) S3
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) S4
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) S5
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) S6
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) L
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) L1
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) L2
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) L3
      READ(NUMIN,'(A)') COM
     READ (NUMIN,*) L4
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) L5
      READ(NUMIN,'(A)') COM
```

```
      READ (NUMIN,*) L6
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) NX
      READ(NUMIN,'(A)') COM
   READ (NUMIN,*) NY
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) NZ
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) PHIDD
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) THEDD
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) PSIDD
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) EPS
      READ(NUMIN,'(A)') COM
   READ (NUMIN,*)DEL1
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*) CHAL
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      IF (CHAL.EQ.2)THEN
      READ (NUMIN,*)PXA
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)PYA
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)PZA
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)AMXA
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)AMYA
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)AMZA
      ENDIF

C*    BYPASSES READING DIRECT INPUT AIRLOADS
   IF (CHAL.EQ.3)THEN
   DO I=1,6
      READ(NUMIN,*) PXA
      READ(NUMIN,'(A)') COM
   ENDDO

      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)VEL
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)ANGA
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)ANGS
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)DEN
      READ(NUMIN,'(A)') COM
      READ (NUMIN,*)R
      READ(NUMIN,'(A)') COM
```

```
          READ(NUMIN,'(A)') COM
          READ(NUMIN,'(A)') COM
          READ(NUMIN,'(A)') COM
          READ (NUMIN,*)SR
          READ(NUMIN,'(A)') COM
          READ (NUMIN,*)LR
          READ(NUMIN,'(A)') COM
          READ (NUMIN,*)C1
          READ(NUMIN,'(A)') COM
          READ (NUMIN,*)C2
          READ(NUMIN,'(A)') COM
          READ (NUMIN,*)C6
          READ(NUMIN,'(A)') COM
          READ (NUMIN,*)C7
          READ(NUMIN,'(A)') COM
          READ (NUMIN,*)CD

      ENDIF
C*        CONVERT IX FROM SLUG-FT**2 TO LB-IN-SEC**2
          IX=12*IX
          IY=12*IY
          IZ=12*IZ
C*        CONVERT DEGREES TO RADIANS
          EPS=EPS/57.2958
          DEL1=DEL1/57.2958
      H=(L5-S5)*TAN(EPS)
      K=H+(L3+S3)
      RETURN
          END

C*   SUBROUTINE CACULATES AIRLOADS TO BE ANALYSED
      SUBROUTINE AIRLOAD
      INCLUDE 'TOPJUNK.INC'
C*   FOR A BATCH FILE INPUTS ARE IN SUBR GETDATA2
      IF (NN.EQ.1)THEN
      IF (CHAL.EQ.1)THEN
      PXA=0
      PYA=0
      PZA=0
      AMXA=0
      AMYA=0
      AMZA=0
      ELSEIF (CHAL.EQ.2)THEN
         WRITE (NUMOUT,*)'INPUT AIRLOADS DIRECTLY FROM WIND TUNNEL DATA'
         WRITE (NUMOUT,*)'INPUT LONGITUDINAL AIRLOAD (PXA)
     >   LB X-DIRECTION POSITIVE AFT'
      READ (NUMIN,*) PXA
         WRITE (NUMOUT,*)'INPUT LATERAL AIRLOAD (PYA)
     >   LB Y-DIRECTION POSITIVE LEFT'
         READ (NUMIN,*) PYA
         WRITE (NUMOUT,*)'INPUT VERTICAL AIRLOAD (PYZ)
     >   LB Z-DIRECTION POSITIVE UP'
         READ (NUMIN,*) PZA
         WRITE (NUMOUT,*)'INPUT LATERAL MOMENT- ROLL (AMXA)
     >   IN-LB POSITIVE CCW LOOKING FORWARD'
         READ (NUMIN,*) AMXA
      WRITE (NUMOUT,*)'INPUT LONGITUDINAL MOMENT- PITCH (AMYA)
     >   IN-LB POSITIVE NOSE UP'
         READ (NUMIN,*) AMYA
         WRITE (NUMOUT,*)'INPUT VERTICAL MOMENT- YAW (AMZA)
     >   IN-LB POSITIVE NOSE LEFT'
```

```
      READ (NUMIN,*) AMZA
      ELSEIF (CHAL.EQ.3)THEN
      WRITE (NUMOUT,*)'CALCULATE AIRLOADS FROM AERODYNAMIC DATA'

C*    DEFINITION OF TERMS
C*    ANGA - ANGLE OF ATTACK OF STORE (DEG)

C*    ANGS - ANGLE OF SIDE-SLIP (DEG)

C*    QUE - DYNAMIC PRESSURE (LB/FT-SQ)

C*    VEL - AIRCRAFT VELOCITY (FT/SEC)

C*    DEN - AIR DENSITY (SLUG/FT^3)

C*    SR - REFERENCE AREA (FT-SQ)

C*    LR - REFERENCE LENGTH (IN)
C*    R-REFERENCE RADIUS (IN)
C*    C1 - LIFT COEFFICIENT SLOPE (PER DEG)

C*    C2 - PITCH MOMENT COEFFICIENT SLOPE (PER DEG)

C*    C6 - SIDE FORCE COEFFICIENT SLOPE (PER DEG)

C*    C7 - YAW MOMENT COEFFICIENT SLOPE (PER DEG)

C*    CD - DRAG COEFFICIENT

      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*) 'ENTER THE AIRCRAFT CARRIAGE CONDITIONS
     > AND ATMOSPHERIC DATA AS PROMPTED'
      WRITE (NUMOUT,*)

      WRITE (NUMOUT,*)'AIRCRAFT VELOCITY - FT/SEC '
      READ(NUMIN,*)VEL
      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*)'ANGLE OF ATTACK - DEG'
      READ(NUMIN,*)ANGA
      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*)'ANGLE OF SIDE-SLIP - DEG'
      READ(NUMIN,*)ANGS
      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*)'AIR DENSITY - SLUG/CUBIC FT '
      READ(NUMIN,*)DEN
      WRITE (NUMOUT,*)'REFERENCE RADIUS - IN'
      READ(NUMIN,*)R

      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*)'WRITE STORE AERODYNAMIC CHARACTERISTICS
     >  (FOR UNKNOWN VALUES, ENTER A "0" AND DEFAULT VALUES
     > BASED ON A CYLINDRICAL SHAPE WILL BE ENTERED'
      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*)'REFERENCE AREA - FT-SQ'
      READ(NUMIN,*)SR
      WRITE (NUMOUT,*)

      WRITE (NUMOUT,*)'REFERENCE LENGTH - IN'
      READ(NUMIN,*)LR
      WRITE (NUMOUT,*)
      WRITE (NUMOUT,*)'LIFT COEFFICIENT - PER DEG'
```

```
          READ(NUMIN,*)C1
          WRITE (NUMOUT,*)
          WRITE (NUMOUT,*)'PITCH MOMENT COEFFICIENT - PER DEG'
          READ(NUMIN,*)C2
          WRITE (NUMOUT,*)
          WRITE (NUMOUT,*)'SIDE-FORCE COEFFICIENT - PER DEG'
          READ(NUMIN,*)C6
          WRITE (NUMOUT,*)
          WRITE (NUMOUT,*)'YAW MOMENT COEFFICIENT - PER DEG'
          READ(NUMIN,*)C7
          WRITE (NUMOUT,*)
          WRITE (NUMOUT,*)'DRAG COEFFICIENT '
          READ(NUMIN,*)CD
       ENDIF
          ENDIF
C*     DETERMINE DEFAULT VALUES
          IF(CHAL.EQ.3) THEN
          IF (SR.EQ.0) THEN
       SR = 3.14159 * ((2 * R / 12)** 2.) / 4
       ENDIF
          IF (LR.EQ.0) THEN
       LR = 22 * R
       ENDIF
C*      'REM L = 11*D
C*      FROM HOERNER P.19-8
          IF (C1.EQ.0) THEN
       C1 = .032
       ENDIF
C*      'REM HOERNER LIFT P. 19-8
          IF (C2.EQ.0) THEN
       C2 = .013
       ENDIF
C*      'REM HOERNER LIFT P. 19-8
          IF (C6.EQ.0) THEN
       C6 = C1
       ENDIF
          IF (C7.EQ.0) THEN
          C7 = C2
       ENDIF
          IF (CD.EQ.0) THEN
       CD = .3
C*     'REM HOERNER DRAG P. 3-12 FIG. 21
       ENDIF
          QUE = DEN * VEL ** 2. / 2

          PXA = CD * QUE * SR
C*      'REM DRAG FORCE
          PYA = C6 * ANGS * QUE * SR
C* 'REM SIDE FORCE ACTING AT .57*LR ASSUME CG (FROM HOERNER)
          PZA = C1 * ANGA * QUE * SR
C* 'REM LIFT FORCE ACTING AT .57*LR ASSUME CG (FROM HOERNER)
          AMXA = 0
C* 'REM ROLL MOMENT
          AMYA = C2 * ANGA * QUE * SR * LR
C*   'REM PITCH MOMENT
          AMZA = C7 * ANGS * QUE * SR * LR
C*   'REM YAW MOMENT
       ENDIF
       RETURN
       END
C*   SUBROUTINE TO ADD INERTIAL LOADS AND AIRLOADS
```

```
      SUBROUTINE ADDLOAD
      INCLUDE 'TOPJUNK.INC'
      PX=ABS(NX*W+PXA)
      PY=ABS(NY*W+PYA)
      PZ=ABS(NZ*W+PZA)
      MX=ABS(PHIDD*IX+AMXA)
      MY=ABS(THEDD*IY+AMYA)
      MZ=ABS(PSIDD*IZ+AMZA)
      RETURN
         END

C*   SUBROUTINE TO RESOLVE STORE COORDINATE SYSTEM WITH AIRCRAFT
C*   COORDINATE SYSTEM
      SUBROUTINE ROTATE
      INCLUDE 'TOPJUNK.INC'
      IF (DEL1.EQ.0)THEN
      PXC=PX
      PYC=PY
      PZC=PZ
      MXC=MX
      MYC=MY
      MZC=MZ
      ELSE
         PXC=PX
      PYC=PY*COS(DEL1)+PZ*SIN(DEL1)
      PZC=PZ*COS(DEL1)-PY*SIN(DEL1)
      MXC=MX
      MYC=MY*COS(DEL1)+MZ*SIN(DEL1)
      MZC=MZ*COS(DEL1)-MY*SIN(DEL1)
      ENDIF
      RETURN
      END

C*   SUBROUTINE CALCULATES FORWARD SWAY BRACE LOADS
      SUBROUTINE FSWYBRC
         INCLUDE 'TOPJUNK.INC'
      A=L5/(2*(S1+L2))+L3/(S*TAN(EPS))
      B=S2*L5/(S*K)
          C=(S2/S)*(.5+L3/K)

      IF (CHSB.EQ.2)THEN
      C=(L2*L3)/(L*(H+S4-L3))
      ELSEIF(CHSB.EQ.3) THEN
      C=(L2/(L2-S1))*(.5+L3/K)
      ELSEIF(CHSB.EQ.4)THEN
      C=(L2*L3)/((L2-S1)*(H+S4-L3))
      ENDIF

      D=S2/(S*K)
      E=.5/(S1+L2)
      F=1/(S*(TAN(EPS)))
      SZFWD=A*PXC+B*PYC+C*PZC+D*MXC+E*MYC+F*MZC
      SYFWD=SZFWD*TAN(EPS)
      STOTFWD=SZFWD/(COS(EPS))
         WRITE(NUMOUT,*)
         WRITE(NUMOUT,*)' SWAY BRACE LOAD LBS'
         WRITE(NUMOUT,*)'VERTICAL=',SZFWD
         WRITE(NUMOUT,*)'LATERAL =',SYFWD
         WRITE(NUMOUT,*)'TOTAL   =',STOTFWD
         NUMOUT=6
         WRITE(NUMOUT,*)
```

```
         WRITE(NUMOUT,*)' SWAY BRACE LOAD LBS'
         WRITE(NUMOUT,*)'VERTICAL=',SZFWD
         WRITE(NUMOUT,*)'LATERAL =',SYFWD
         WRITE(NUMOUT,*)'TOTAL   =',STOTFWD
      NUMOUT=11
      RETURN
      END

C*   SUBROUTINE CALCULATES AFT SWAY BRACE LOADS
         SUBROUTINE ASWYBRC
         INCLUDE 'TOPJUNK.INC'
         A=L5/(2*(S2+L1))+L3/(S*TAN(EPS))
         B=S1*L5/(S*K)
         C=(S1/S)*(.5+L3/K)

         IF (CHSB.EQ.5)THEN
         C=(L1*L3)/(L*(H+S4-L3))
         ELSEIF(CHSB.EQ.6) THEN
         C=(L1*(L1-S2))*(.5+L3/K)
         ELSEIF(CHSB.EQ.7)THEN
         C=(L1*L3)/((L1-S2)*(H+S4-L3))
         ENDIF

         D=S1/(S*K)
         E=.5/(S2+L1)
         F=1/(S*(TAN(EPS)))
         SZAFT=A*PXC+B*PYC+C*PZC+D*MXC+E*MYC+F*MZC
         SYAFT=SZAFT*TAN(EPS)
         STOTAFT=SZAFT/(COS(EPS))
         WRITE(NUMOUT,*)
         WRITE(NUMOUT,*)' SWAY BRACE LOAD LBS'
         WRITE(NUMOUT,*)'VERTICAL=',SZAFT
         WRITE(NUMOUT,*)'LATERAL =',SYAFT
         WRITE(NUMOUT,*)'TOTAL   =',STOTAFT
         NUMOUT=6
         WRITE(NUMOUT,*)
         WRITE(NUMOUT,*)' SWAY BRACE LOAD LBS'
         WRITE(NUMOUT,*)'VERTICAL=',SZAFT
         WRITE(NUMOUT,*)'LATERAL =',SYAFT
         WRITE(NUMOUT,*)'TOTAL   =',STOTAFT
         NUMOUT=11
         RETURN
         END

C*   SUBROTINE TO CALCULATE FORWARD HOOK LOAD
      SUBROUTINE FHOOK
         INCLUDE 'TOPJUNK.INC'
      AY=0
      BY=(S2/S)*((L5*(TAN(EPS))/K)-1)
C*   FIND SIGN OF BY
      I=S5*TAN(EPS)-(S3+L3)
      IF(I.LT.0)THEN
      BY=-BY
      ELSEIF(I.GT.0)THEN
      BY=BY
      ELSE
      BY=0
      ENDIF
      CY=L2*L3*TAN(EPS)/(L*(H+S4-L3))

         IF (CHHL.EQ.2 .OR. CHSB.EQ.2 .OR. CHSB.EQ.4)THEN
```

```
          CY=(S2*L3*TAN(EPS))/((S2-L1)*(H+S4-L3))
          ENDIF

      DY=S2*TAN(EPS)/(S*K)
      EY=0
      FY=0
      AZ=L5/(S2+L1)+L3/(S*TAN(EPS))
      BZ=S2*L5/(S*K)
      CZ=(L2/L)*(L3/(H+S4-L3)+1)

          IF (CHHL.EQ.2 .OR. CHSB.EQ.2 .OR. CHSB.EQ.4)THEN
          CZ=(S2/(S2-L1))*(L3/(H+S4-L3)+1)
          ENDIF

      DZ=S2/(S*K)
      EZ=1/(S2+L1)
      FZ=1/(S*TAN(EPS))
      LXFWD=PXC
      LYFWD=BY*PYC+CY*PZC+DY*MXC
      LZFWD=AZ*PXC+BZ*PYC+CZ*PZC+DZ*MXC+EZ*MYC+FZ*MZC
      LTOTFWD=(LXFWD**2+LYFWD**2)**.5
          WRITE(NUMOUT,*)
          WRITE(NUMOUT,*)'   FORWARD HOOK/LUG LOADS LBS'
          WRITE(NUMOUT,*)'VERTICAL       =',LZFWD
          WRITE(NUMOUT,*)'LATERAL        =',LYFWD
          WRITE(NUMOUT,*)'LONGITUDINAL   =',LXFWD
          WRITE(NUMOUT,*)'TOTAL SHEAR    =',LTOTFWD
          WRITE(NUMOUT,*)
      NUMOUT=6
          WRITE(NUMOUT,*)
          WRITE(NUMOUT,*)'   FORWARD HOOK/LUG LOADS LBS'
          WRITE(NUMOUT,*)'VERTICAL       =',LZFWD
          WRITE(NUMOUT,*)'LATERAL        =',LYFWD
          WRITE(NUMOUT,*)'LONGITUDINAL   =',LXFWD
          WRITE(NUMOUT,*)'TOTAL SHEAR    =',LTOTFWD
      NUMOUT=11
      RETURN
      END

C*   SUBROTINE TO CALCULATE AFT HOOK LOAD
          SUBROUTINE AHOOK
          INCLUDE 'TOPJUNK.INC'
          AY=0
          BY=(S1/S)*((L5*(TAN(EPS))/K)-1)
C*   FIND SIGN OF BY
          I=S5*TAN(EPS)-(S3+L3)
          IF(I.LT.0)THEN
          BY=-BY
          ELSEIF(I.GT.0)THEN
          BY=BY
          ELSE
          BY=0
          ENDIF
          CY=L1*L3*TAN(EPS)/(L*(H+S4-L3))

      IF (CHHL.EQ.3 .OR. CHSB.EQ.2 .OR. CHSB.EQ.7)THEN
      CY=(S1*L3*TAN(EPS))/((S1-L2)*(H+S4-L3))
      ENDIF
          DY=S1*TAN(EPS)/(S*K)
          EY=0
          FY=0
```

```
      AZ=L5/(S1+L2)+L3/(S*TAN(EPS))
      BZ=S1*L5/(S*K)
      CZ=(L1/L)*(L3/(H+S4-L3)+1)

      IF (CHHL.EQ.3 .OR. CHSB.EQ.2 .OR. CHSB.EQ.7)THEN
   CZ=(S1/(S1-L2))*(L3/(H+S4-L3)+1)
      ENDIF
      DZ=S1/(S*K)
      EZ=1/(S1+L2)
      FZ=1/(S*TAN(EPS))
      LXAFT=PXC
      LYAFT=BY*PYC+CY*PZC+DY*MXC
      LZAFT=AZ*PXC+BZ*PYC+CZ*PZC+DZ*MXC+EZ*MYC+FZ*MZC
   LTOTAFT=(LXAFT**2+LYAFT**2)**.5
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'   AFT HOOK/LUG LOADS LBS'
      WRITE(NUMOUT,*)'VERTICAL      =',LZAFT
      WRITE(NUMOUT,*)'LATERAL       =',LYAFT
      WRITE(NUMOUT,*)'LONGITUDINAL  =',LXAFT
      WRITE(NUMOUT,*)'TOTAL SHEAR   =',LTOTAFT
      WRITE(NUMOUT,*)
   NUMOUT=6
      WRITE(NUMOUT,*)
      WRITE(NUMOUT,*)'   AFT HOOK/LUG LOADS LBS'
      WRITE(NUMOUT,*)'VERTICAL      =',LZAFT
      WRITE(NUMOUT,*)'LATERAL       =',LYAFT
      WRITE(NUMOUT,*)'LONGITUDINAL  =',LXAFT
      WRITE(NUMOUT,*)'TOTAL SHEAR   =',LTOTAFT
   NUMOUT=11
      RETURN
      END
```

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